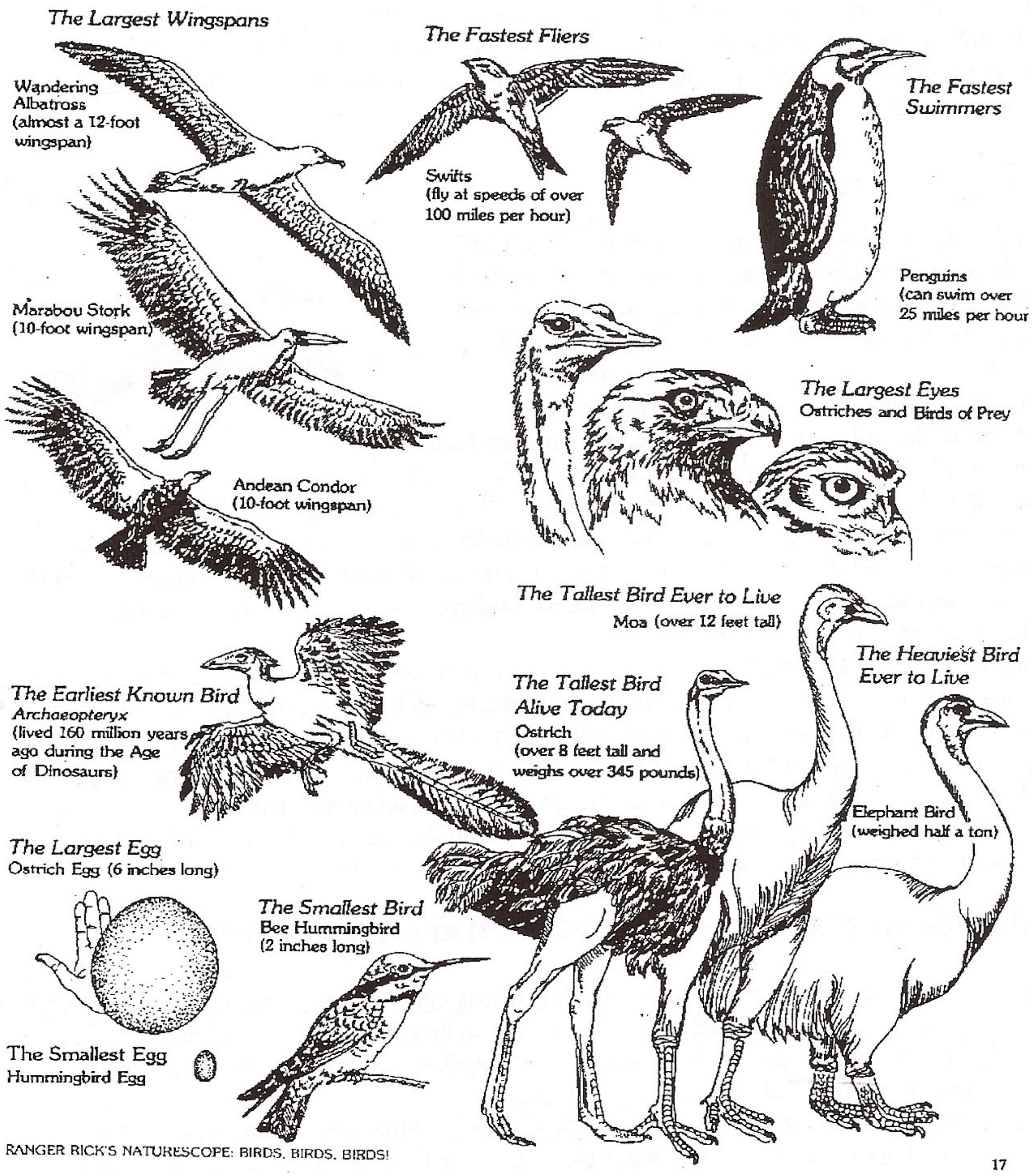
BIRDS



The Largest Wingspans
Wandering Albatross (almost a 12-foot wingspan)
Marabou Stork (10-foot wingspan)
Andean Condor (10-foot wingspan)
The Fastest Fliers
Swifts (fly at speeds of over 100 miles per hour)
The Fastest Swimmers
Penguins (can swim over 25 miles per hour
The Largest Eyes
Ostriches and Birds of Prey
The Tallest Bird Ever to Live
Moa (over 12 feet tall)
The Heaviest Bird Ever to Live
Elephant Bird (weighed half a ton)
The Earliest Known Bird
Archaeopteryx
(lived 160 million years ago during the Age of Dinosaurs)
The Tallest Bird Alive Today
Ostrich
(over 8 feet tall and weighs over 345 pounds)
The Largest Egg
Ostrich Egg (6 inches long)
The Smallest Bird
Bee Hummingbird (2 inches long)
The Smallest Egg
Hummingbird Egg
RANGER RICK'S NATURESCOPE: BIRDS, BIRDS, BIRDS!
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BIRDS! **[See Dinos-Birds in the Docent Notebook http://www.sfzoodocents.org/notebook/STUDY%20GUIDES/BoneCart/Dinos-Birds.pdf]**
Of the five classes of vertebrates (fish, amphibians, reptiles, birds & mammals) the birds Class Aves) are often most easily observed by the average person. Though people may not know that there are over 9,000 species of birds found in 28 orders, 163 families and 1,975 genera, most people will be able to tell you at least one characteristic of birds. When asked, most people will mention: all birds have feathers, all birds lay eggs and all birds have wings- even the flightless birds (ostriches, emus & relatives; penguins and others).

Humans are familiar with birds, because like us, they are active during the day, and rely primarily on their senses of vision (they see in color) and hearing. Wherever people go, they will see birds - whether in the city or country. Birds are all around us if we take the time to notice them. (You will notice a number of wild birds, especially during spring and fall migration that frequent the Zoo because of its extensive plantings.)

BIRD EVOLUTION

Birds arose from reptiles as did the mammals, but much later and from different reptilian ancestors. The fossil record shows that birds descended from lizard-like reptiles about 160 million years ago during the Jurassic Period. Many scientists now propose that modern day birds are living representatives of the dinosaurs!

When we talk of evolution of birds, we nearly always first think of the oldest known fossil bird, called ***Archaeopteryx lithographica***. It was discovered in 1860 in limestone deposits in Germany. *Archaeopteryx* (meaning means "ancient wing") possessed characteristics of both birds and reptiles and was viewed as the perfect example of an "intermediate" species that bridged the gap between two major classes of vertebrate groups. *Archaeopteryx* was more dinosaur-like than bird-like. It had an opposable hallux that was probably used for perching, and better eyesight like modern birds. Like a dinosaur, it did not have a beak, instead possessing a scaly snout full of sharp, cone-shaped teeth. It had a long, bony tail, claws, an unfused pelvis, an S-shaped neck, and the spine was attached *behind* the skull, rather than below as in modern birds.

Archaeopteryx's most prominent bird-like feature was feathers, evolved from reptilian scales, that were most-likely used for short-term flight. The primary feathers were asymmetrical, suggesting *Archaeopteryx* had powered flight but the unkeeled sternum suggests their powers of flight were weak. Archaeopteryx was capable of gliding and weak flapping but not of long, sustained flight. There is still a debate whether feathers evolved for flight or evolved for other reasons (i.e. thermoregulation) and secondarily modified for flight. The combination of reptilian and avian characteristics clearly shows that *Archaeopteryx*, and therefore birds, are derived from some ancestral stock of reptiles.

***Archaeopteryx* characteristics:**

- Bipedal
- Feathered (asymmetrical feathers – necessary for powered flight)
- Furcula or "wish-bone" (fused collarbones) – probably anchored pectoralis muscles
- Possibly endothermic

By the end of the Cretaceous (65 million years ago), a number of modern day birds, were present, including flamingo, loons, grebes, cormorants, rails and shorebirds. By the Eocene (63 million years ago), most of the present day orders had evolved; with 28 modern families showing up in the fossil record. Perhaps the greatest diversity of birds showed up in the fossil record 25 million years ago (in the Miocene). Scientists estimate that there were over 10,500 bird species alive at that time. A number of species and families have since become extinct.

During the Pleistocene (1 million years ago), all modern orders and families were in existence, with most modern species present. Tremendous climate change took place at this time and the effects of glaciations on the distribution of vegetation greatly affected all life on earth. Migration/dispersal patterns were disrupted at this time. While Pleistocene glaciers led to extinctions, it was also a time of great radiation and speciation as habitats contracted and expanded.

The differentiation of geographic races (sub-species) of birds became evident in the recent past (15,000 years ago), especially among the perching birds (Order Passeriformes).

MAJOR BIRD CHARACTERISTICS COMPARED WITH REPTILES & MAMMALS

Birds still show many reptilian attributes including laying eggs, having scales on their beaks and legs, and partially hollow bones. Birds and reptiles also share some similarities in many internal features (arrangement of skull, ear and bone features as well as some physiological traits - nucleated red blood corpuscles, large amount of uric acid in urine, embryology, etc.).

Only birds and mammals are endothermic. More than any other trait, this ability to maintain a constant, high body temperature has allowed birds and mammals to live in all possible habitats and at all seasons. Like mammals, birds have a four chambered heart and separate systems for venous and arterial blood.

Bird Characteristics:

- Bipedal
- Feathers
- Wings
- Egg-laying
- Furcula
- Uncinate processes of rib (providing bracing to the rib cage)
- Syrinx
- Stapes (single middle ear bone)
- Sight into UV light
- Hearing into infrasound
- Flight (most species)

BIRDS IN FLIGHT

Most major characteristics of birds can be directly related to their adaptations for flight. The adaptations for flight include:

- Feathers and powerful wing muscles
- Endothermic for power
- Highly efficient respiratory system
- Large strong four-chambered heart
- Reduced weight – skeleton weighs less than all its feathers
- Centralized mass

FEATHERS **[See article "Bird Feather Types, Anatomy, and Molting" p 19-22 below for more details.]**

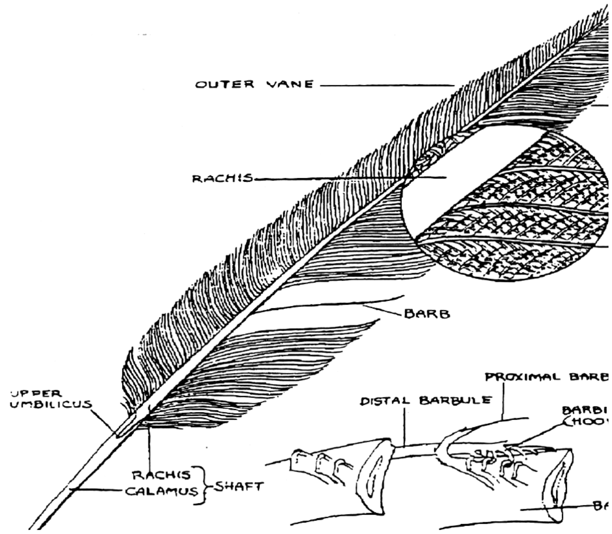
Unlike any other kind of animal, all birds grow feathers (a kind of modified scale made of **keratin**). Birds have several different kinds of feathers, which serve a number of purposes. The two main types of feathers are contour feathers (found on the bird's body wings and tail) and down feathers (soft, fluffy feathers which are under the contour feathers). Besides facilitating flight and providing buoyancy in air and water, feathers insulate birds and protect their sensitive skin. Because birds see in color, feathers come in all different colors and patterns. These colorful feathers are important in courtship behavior and recognition. In addition, these pigmented feathers are stronger than unpigmented ones and stop harmful ultraviolet rays from burning the skin. Females of many species have cryptic coloration (camouflage).

Most birds have a special oil gland (preen gland) just above the base of the tail. Birds rub this secretion over their feathers with their beaks to condition and clean them. Warn and faded feathers are replaced regularly by molt - new feathers push out the old ones. Molt often involves a change in color such as the difference in breeding and winter plumage, or the change from juvenile to adult coloration. Most passerine birds have a typical molt where a few feathers are lost at a time, in a bilaterally symmetrical sequence over a period of many weeks. The usual pattern is a complete molt after the breeding season and an incomplete molt in the spring.

Feathers are attached to birds in distinct patches called **pterylae** patches in most kinds of birds, especially those birds that fly. The spaces on the bird's body without feather tracts are called **apteria**. The densest area for feathers is often on the bird's head and neck. The primary reason feathers are grouped into tracts appears to be for weight conservation.

Some birds do have fairly uniform distributions of feathers on their bodies. These species lacking bare patches include some familiar birds like penguins, which have tiny feathers that look like hair and are excellent at keeping cold air and water out but warm air in; ostriches, which lack apteria as adults but have them as embryos; and ducks, which have contour feathers in tracts but down feathers are distributed everywhere.

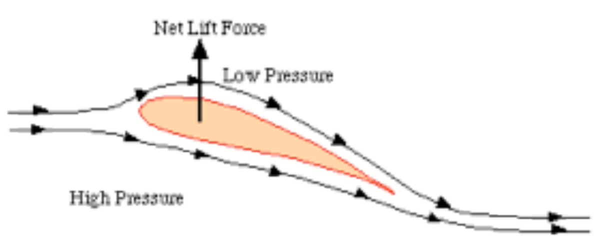
This diagram shows the main components of a contour feather. The rachis, or shaft, holds the barbs. On the barbs are the barbules and the barbicels, or hooklets. The “rigid” structure of the contour feather prevents air from passing through the feather. This and the feather’s’ streamlined shape facilitates lift and propulsion. (Ratites, flightless birds, do not have barbicels. Air passes through their feathers).



<u>TYPE</u>	**<u>PURPOSE</u>**
Contour	Form the outline of the bird and include body, tail, and large wing feathers.
Down	Insulation is the main function of these feathers
Powder Down	Similar to down feathers, but grow continuously. Produce a fine, water-resistant powder.
Semiplume	Lack hooklets. Unconnected barbs are lax so therefore there are no vanes. Primary function is trapping air for thermal insulation.
Filoplume	Lax, hair-like feather that has barbs only at the tip. Their function is probably sensory.
Bristle	A modified filoplume located around the eyes and mouth. Their primary function is probably tactile.

DYNAMICS OF FLIGHT

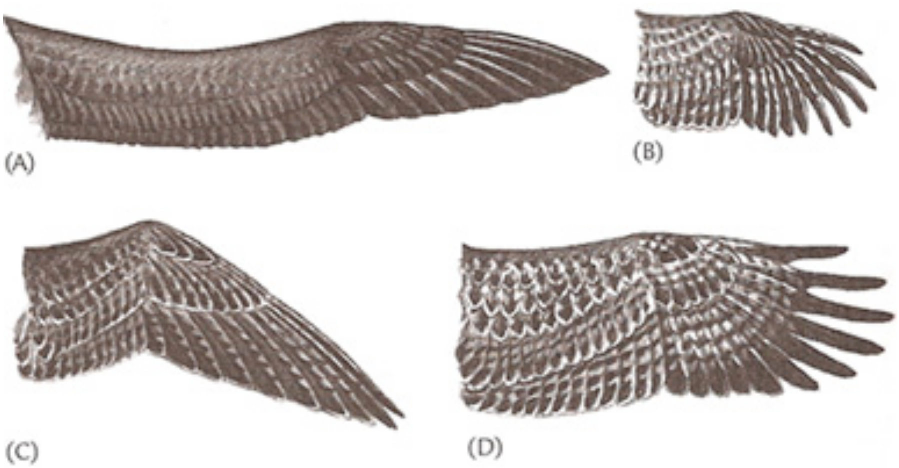
- The largest muscles are attached to the keel of the breastbone (sternum); when contracted, they produce a down stroke of the wings, which provides forward propulsion. Relaxing the muscles bring the wing back
- Wings are curved convexly over the top edge which creates a greater pressure underneath the wing and produces lift, just like an airplane
- On the upstroke, birds keep the wings closer to its body. On the downstroke, the wings are fully extended for power
- Tail feathers are important for steering and landing
- Wing shape depends on lifestyle; fast flyers like swifts and falcons have long pointed wings. Soaring birds have broad, large wings to gain lift from thermal air pockets
- Flightless birds such as emus and ostriches do have wings, but they are greatly reduced in size.



TYPES OF BIRD'S WINGS

Flight abilities vary with the shape of a bird's wings. In example A (ie. albatross), a long, narrow, pointed wing is best for high-speed soaring especially in high winds. The wings are much longer than they are wide. There is a lot of vertical lifting area, which comes from the long forward leading edge of the wing.

Example B (ie. grouse), the short, rounded wings permit fast takeoffs and rapid maneuvers but the high speed cannot be maintained. Other birds with this wing type are and sparrows, crows and robins as well as gamebirds such as pheasants and turkeys.



The slim, unslotted wings of example C (ie. falcons) allow fast, efficient flight in open habitat. These wings are not as long as active soaring wings of the albatross (example A). The narrow wings come to a sharp tip, which reduces drag and produces a greater forward thrust. These birds are incredibly fast, but also can maintain their speed for a while. Other examples of birds with this wing type are swifts, ducks, falcons, terns, and sandpipers.

Wing slots are created when long primary feathers are spread out. These "slots" can catch thermals and rise higher in the air; they provide and increase lift and gliding ability. Example D, (ie. hawks) the slots in wings of intermediate dimensions provide passive soaring. Examples of birds with this wing type include eagles, vultures, most hawks, and storks.

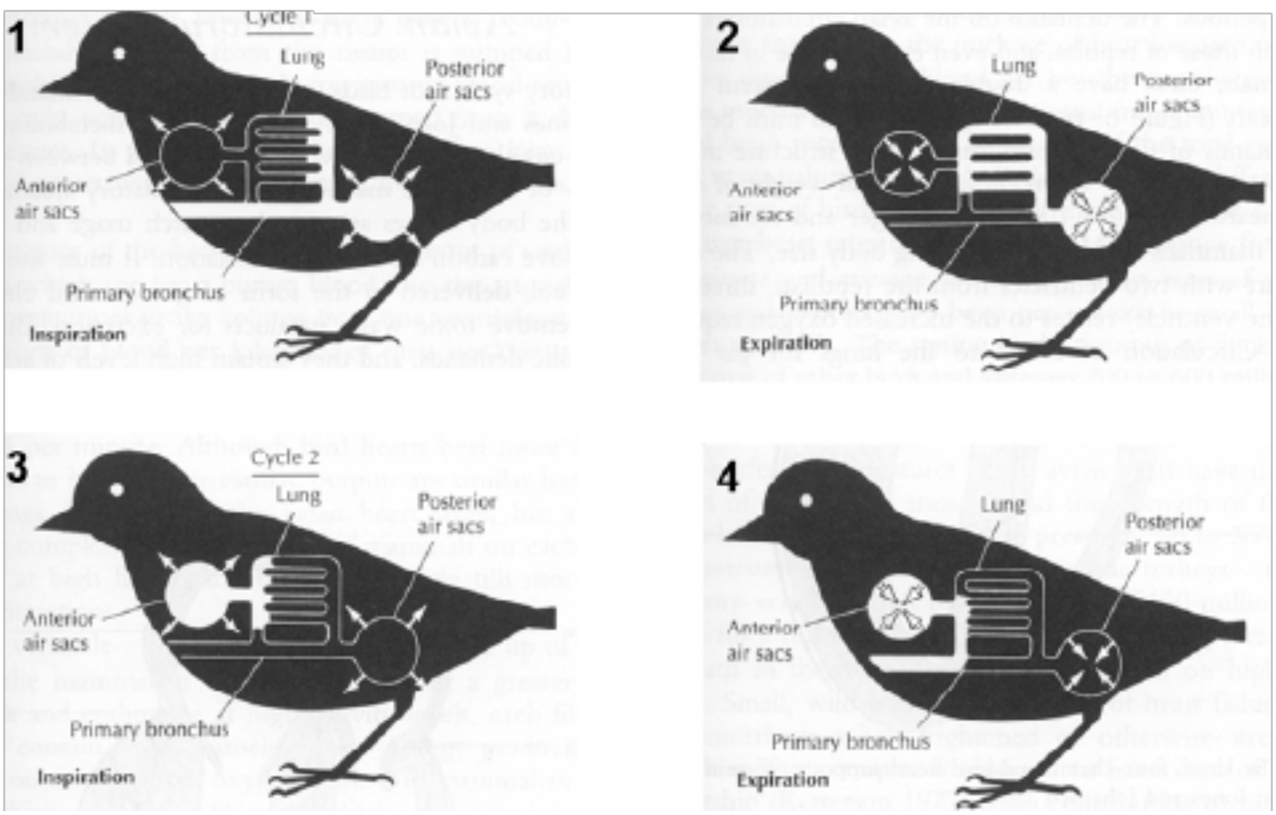
PHYSIOLOGY & ANATOMY

In order to fly, birds must be light with a compact skeleton. One adaptation is penumatized bones with criss-crossing struts or trusses for structural strength. Another adaptation is fusion of forelimb bones to form the wings. General reduction in the size and number of bones also helps make birds lighter. Birds have long bones in their wings and legs that provide greater strength.

Birds have many other skeletal adaptations that enable them to fly. Their sternum is shaped like a keel so that the large wing muscles required for flight can be attached. The large wing and leg muscles are positioned near the bird's center of gravity for better aerodynamics balance. The dermal muscles allow erection, depression, and lateral movement of feathers, which is important in controlling body temperature and the care of the feathers.

Birds have also lost body parts during their evolution to aid in flight, including one ovary, one oviduct, skin glands, teeth, urinary bladder, and urethra, and seasonally, the reduction in the size of gonads giving them increased weight reduction for animals their size. Birds carry this weight as close to the center of gravity as possible giving them better maneuverability in flight.

Birds have an excellent respiratory system that aids in flight. Most birds have nine air sacs, which help maximize the exchange of oxygen into the bloodstream and gives the aquatic bird extra buoyancy. Inspired air passes first through the posterior air sacs, then into the lungs and finally through the anterior air sacs before leaving the bird. The air sacs act as a bellows, pushing a unidirectional flow of air through the lungs where gas oxygen occurs. By transferring more air and air higher in oxygen content during each breath, birds achieve a more efficient rate of gas exchange than do mammals. A bird's respiratory system is especially efficient at altitudes.



Two full respiratory cycles – inspiration and expiration are required to move the gas through its complete path.

Cycle 1:

1 - On first inhalation, air flows through the trachea and primarily into the posterior (or caudal) air sacs.

2 - On exhalation, air moves from the posterior air sacs & into the lungs where gas exchange occurs. Here oxygen diffuses from the air into the blood and carbon dioxide diffuses from the blood to lungs. Air flow and blood flow are opposite in direction and thus a counter current exchange of gas occurs permitting a greater gas exchange.

Cycle 2:

3 - With the second inhalation, the air from the first inhalation moves from the lungs & into the anterior air sacs.

4 - With the second exhalation, air moves from the anterior air sacs back into the trachea & out.

Like mammals, birds have a four-chambered heart with an efficient double-circuit circulation; oxygenated blood flowing from the lungs to the body does not mix with blood flowing back from the body carrying wastes to be expelled once in the lungs. Birds tend to have larger hearts than mammals (relative to body size and mass) and also tend to pump more blood per unit time. This circulatory system is much more efficient for moving oxygen to cells into the body and permits birds to meet the high metabolic demands of flight and other aerobic activities.

Birds and reptiles, which must conserve water, excrete nitrogenous waste as uric acid. Uric acid uses less water than the urea of mammals. Uric acid eliminates twice the amount of nitrogenous waste and since it is not water soluble, less water is needed for elimination. Uric acid is an thus an adaptation for reduced body weight. Also, uric acid can be stored more easily in the egg.

SENSES

Most birds have excellent hearing; relying on their hearing to find mates and detect danger. Through songs and calls they communicate with others. Their ears are located just below and in back of their eyes. Unlike most mammals, birds have a poorly developed sense of smell. Most scientists think only turkey vultures, kiwis and a few other species use their sense of smell (as well as other senses) to find food. Their sense of taste is poorly developed. They have only 40 taste buds as compared to about 9000 in humans.

The vision of birds is their keenest sense. Their eyes are the most developed of any other animal and are relatively large for their size. They can detect tree-dimensional depth, distance, direction, size, shape, brightness, and color - hue and intensity. Birds also see a wider range of wavelengths than humans, including many species that can see ultraviolet light (UV). What these differences mean to birds remains to be determined, but early work indicates it may help with locating food for raptors, frugivores, and nectarivores. To protect their eyes, birds have a lower and upper eyelid similar to mammals, but they also have a third eyelid called the **nictitating membrane**. The nictitating membrane serves the main role of lubricating and cleaning the cornea of debris.

FEEDING ADAPTATIONS

Because of their greater activity, birds require more energy than most other vertebrates. The body temperature of birds is generally higher than mammals (ranging from 100 - 112° F). A high body temperature is needed to maintain a high metabolic rate - which is related to high energy/activity. Birds are adapted for “high energy” foods such as seeds, fruits, and meat - insects, fish, rodents, etc.

This accelerated” metabolism also requires an effective digestive system. Although this system is similar to that of reptiles and mammals, the digestive system of birds shows a number of “specializations” that support their special needs for “fast energy”. In addition, the digestive system of birds is adapted for flight - weight reduction. There are no heavy jaws or teeth.

Generally, the digestive system of birds is adapted either for a carnivorous or herbivorous diet. Specialization for either a plant or animal diet is evident from the beak to the feet. (be sure to point out beaks and feet when you are on a tour or station). Bird beaks are extremely varied, depending on the kind of food they consume. Although beaks are used to gather nest materials and in preening, the main function of the beaks is to expose, capture, kill and manipulate food for swallowing. One of the best ways to see how a bird is adapted to its habitat is to look at its beak. For example, seed eaters have strong, conical beaks which enable them to crack hard seed coats. Birds of prey (raptors) have curved, sharp beaks, which act like meat hooks. Hummingbirds have long, thin beaks, which can probe flowers for nectar. The tongues of each of these birds are also adapted for a particular diet. **[See BEAK illustration on page 10 for examples of variously shaped beaks.]**

Once swallowed, food passes through the muscular esophagus, which is lined by a thick, protective membrane. In some birds, the esophagus has a large storage chamber / swelling called the **crop**. Food stays in the crop until it is ready to be passed on to the stomach or later regurgitated to the chicks. Crops are a wonderful adaptation because they allow birds to quickly store large amounts of food, thereby reducing the time a bird is vulnerable to predation. The crops tend to be largest in birds that eat larger seeds. Although no digestive glands are known to exist in the crop, it does contain mucous - which softens hard items before they are digested in the stomach and intestines.

Birds have a two-chambered stomach. Closest to the esophagus and crop is the glandular stomach (**proventriculus)**. The glandular stomach secretes acidic enzymes and gastric juices that digest food (chemical digestion). In meat-eating birds, this act to digest both flesh and bone. The second stomach chamber is the muscular stomach or **gizzard**. This is the site for mechanical digestion. Generally, it is the herbivore (especially the seed-eaters) and birds, which eat shelled animals that have a powerful, muscular gizzard for grinding. The mastication (grinding) of food in the gizzard is further assisted in most birds (especially the seed-eaters) by grit, sand or pebbles, which these birds swallow. For many of the carnivorous birds, the gizzard is also a “stop” to prevent sharp bones and indigestible items from passing further. These birds then regurgitate a “pellet” of undigested bone, fur, teeth, etc. (Interestingly, biologists have learned much about the diet of raptors by examining their pellets).

The structure and function of bird feet are as varied as beaks. Aquatic birds have webbed feet for paddling (ducks, etc.). Birds that frequent marshes either have extremely long toes for walking on floating vegetation or long legs and long necks. Emus, ostriches and kin have strong legs and short toes, which point forward. Raptors have strong grasping feet and sharp talons. The form of feet is as diverse as the function they serve. **[See FEET illustration on page 11 for types of bird feet.]**

BIRD BEAK SHAPE Illustration: A bird's beak is its key adaptation for feeding. The size, shape and strength of the beak indicate the potential diet.

White-throated sparrow with its light bill adapted to small seeds and plant material; heavy seed-cracking bill of the **evening grosbeak**; the tall but thin bill of the **Atlantic puffin** adapted to catching and holding small fish;

the probing bill of the **golden-winged warbler** adapted to feeding on small insects; the long bill of the **whimbrel** adapted to probing mudflats for small invertebrates; the **pileated woodpecker** with its long, heavy bill for chopping away wood to expose insects;

the **keel-billed toucan** which feeds on fruits of rainforest trees; the **great blue heron** with its long bill for stabbing and seizing small animals and fish;

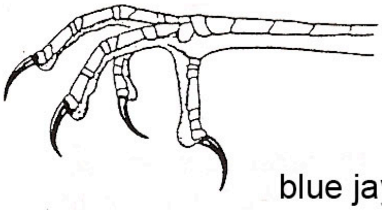
the unique bill of the **greater flamingo** which houses a complex filtration system to strain small invertebrates from shallow mud flats and lakes; the **sword-billed hummingbird** with its extremely long bill for probing deep into the bells of tubular tropical flowers;

and the sharp, decurved bill of the **red-tailed hawk** adapted to tearing flesh from the small mammals on which it feeds.

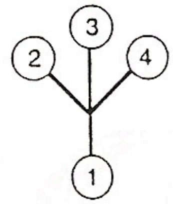
BIRD FEET ILLUSTRATION:

Type of foot	Toe configuration	Notes

ANISODACTYL

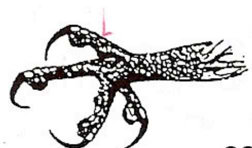


blue jay

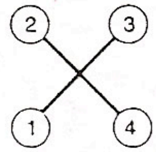


The anisodactyl foot is the most common arrangement of the avian toes. Songbirds and most other perching birds have anisodactyl feet. The ringed turtledove and crow have this type of foot.

ZYGODACTYL

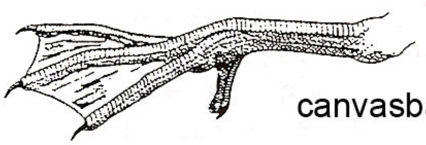


osprey

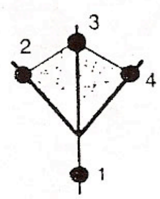


The zygodctyl foot is the second most common toe arrangement in perching birds. It is found in the osprey, most woodpeckers, and psitticines. The military macaw has this type of foot.

PALMATE

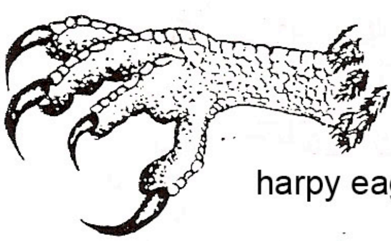


canvasback

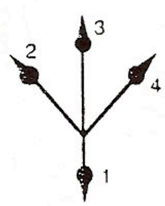


The palmate is the most common type of webbed foot and is found in ducks, geese, swans, gulls, and other aquatic birds. Totipalmate is having all four toes united by a web, as in the pelican & cormorant.

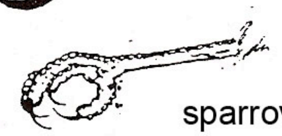
RAPTORIAL



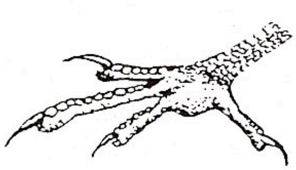
harpy eagle



Long, strong digits armed with heavy claws for catching, holding, and killing prey animals characterized the raptorial foot. Raptorial feet are found in kites, hawks, eagles, and falcons.



sparrow hawk



vulture
(has a weak raptorial foot)

COURTSHIP, MATING, NESTING AND REARING OF YOUNG

TERRITORIES

Except in a few cases the establishment of territories is the first step in the onset of courtship. In migratory birds, males arrive to a nesting site first and begin selecting and defending territories' from other males. Reasons for setting up these territories involve courtship, nest sites and feeding. Dominant, "fittest" males generally claim territories with the best resources for rearing young. The female birds arrive to the nesting area soon after the males, with immature birds following last. Once a male has successfully selected an area he will set about attracting an arriving female. This is done in several different ways - song, plumage, and or some sort of display of flight. Song is one means of communication for birds. Songs are species specific, but there seems to be some universal sounds that all birds recognize: those of distress, warning and the hunger of young. Most often it is the male that sings. If the female also sings the males song is more complex. In attracting a female, the male may perch himself in a conspicuous part of his territory and sing. To another male this song may signal to stay away and to a female it is an invitation to take a closer look. For most birds, song is usually heard during courtship, mating and continues through the raising of the young. It then ceases until the following year.

PLUMAGE

Plumage, coloration and presentation, is another form of communication. In species where the males display bright colors, they do so only during the breeding season. They molt to more drab coloring for the remainder of the year. Since females with bright plumage might attract predators to the nest, their coloration tends to blend with their surroundings. For some birds plumage plays a larger part in attracting a female than that of song. The peafowl is a prime example, the cock grows the most impressive set of tail feathers each year for the simple reason of attracting a female. Some birds use a courtship 'dance' along with plumage to attract a female, or tighten a bond with an attracted female. Some males use acrobatic flight while other males build nests to entice the female. In each case the male is attempting to prove he is the best candidate for a mate.

NESTS

Once a mate has been selected and a bond of sorts develops, the pair goes about building a nest. Most often it is the female who builds the nest, but there are some birds where the males do mast of the work. A nest can be as simple as a depression or hollow scratched out in the ground, or as complex as an intricately woven nest that hangs from the branches of a tree. The material used for nest building varies, from grasses, twigs, sticks, the hollow of a tree or branch, to mud and decaying material. Many nests are lined with feathers plucked from the female's body. There are a few birds, such as the Emperor, King Penguins and the Waved albatross that do not build nests at all. The Emperor penguin incubates its eggs on its feet.

EGGS

A female will generally begin laying eggs soon after the nest is completed. Incubation generally does not begin until all eggs have been laid. This insures that all the eggs will hatch at the same time. Often about this time the bird will develop a brood spot in the middle of their breast. This area is usually bare of feathers and engorged with blood. Many males will participate in the duties of feeding the females while she lays her clutch and during incubation. Some males actually sit on the eggs while the female forages for food. Often the female is the primary incubator for the eggs, but there are a few birds that have reversed this role entirely. The emu and cassowary males sit on the nests and raise the young while the females leave to mate with other males. As a general rule, larger eggs take longer to hatch and the chicks are usually precocial, while smaller eggs take a shorter time to hatch and the chicks are generally altricial.

The ostrich and emu take 50 - 60 days and 70 - 80 days respectively. The duration of time that the eggs are left unattended seems to add to the time it takes for the young to develop and hatch. The hummingbird, having the smallest eggs, requires 14 - 15 days; they are often left while the female forages for food. This causes the eggs to loose heat therefore extending the time required. In another case the cowbird requires only 11 days. One theory for this is that since they are laid in the nest of other birds, they need to hatch first allowing them to get a jump on food and growth size in order to push out the eggs laid by the owner of the nest. Incubation involves rotating the eggs and moving their position to maximize heat distribution. This is done two or three times a day.

The shape of eggs varies considerably depending on the birds and the type of nesting site. The shapes range from almost round to rather pointed, though most are oval. Egg coloration often aids with camouflage. Birds that build nest on the ground tend to have earthy colored eggs with speckles that allow them to blend into the surrounding area. Some birds that have nests in the open actually have white eggs. A possible explanation for this is, if the nest is in an area that cannot be defended properly and the egg is taken by a predator, it is better to lose the egg early, when a new nest can be built and another egg can be laid and hatched.

RAISING YOUNG

Feeding of the young is usually a project undertaken by both parents. Most altricial young are fed on regurgitated food. The parent bird feed and returns to the nest. They allow their young to place their beaks and head into their mouth to feed. When a chick has taken enough food during a feeding to fill it's crop, the muscles of its throat constrict. The parent then moves on to the next chick. Some birds feed their young with live prey. The parent places the item into the chick's mouth and throat so that it does not escape. As the chick matures the parent will not place the food as deep forcing the chick to learn about moving food. When the chick learns to fly the parent will feed the young less and less, and may even just drop live food into the nest. The young must either catch it in flight or when it lands. The young begin to fend for themselves as they learn to fly. After they are self-sufficient the bond of parent / chick is broken.

Courtship, mating and rearing of young is one of most energy expending events in a bird's life. Some birds have only one young per season while others may have several clutches with multiple chicks. Each is designed to ensure the survival of the species, and is regulated by the resources and the threat of predators.

THE ECOSYSTEM PERSPECTIVE:
BIRD HABITATS, NICHES, MIGRATION, AND CONSERVATION

HABITATS & NICHES

More than 9,000 species of birds share the world around us, inhabiting the planet in incredible variety. Their habitats include: open sea, polar ice caps, equatorial deserts, mountain peaks, high altitude soda lakes, tropical jungles, savannas, and backyards, to list just a few.

Even in seemingly simple habitats, bird species divide up space and food resources through behaviors and adaptations that allow them to coexist without direct competition. Each species feeds differently, searching different layers of the forest or shoreline, using unique search or capture techniques. In the complex and food rich environments, such as tropical forest, niche varieties seem almost endless. It is important to remember that birds are a part of and provide many services to, the environments they inhabit. While insects are the world's greatest pollinators, many species of plant rely solely on birds for their reproductive success. For example, it is a valid rule of thumb that any large red flower (although it is not limited to these) is likely to be bird-pollinated. Birds have good color vision and see red as a bright attractive color, (just as we do). The flowers need to be relatively large to be attractive to these relatively larger (than insects) pollinators. Many birds survive at least part of the year on fruits and some are true frugivores. Some plants specialize in attracting specifics species of birds, which make excellent seed dispersers. Many seeds even germinate more readily after passing through a bird's digestive tract. Higher up the food web, and just as important, many species of birds are predators. Eagles, hawks, and other raptors have always been impressive symbols of strength to humankind, who observe their hunting techniques. However, it is equally important to remember all the predatory insect-eating birds, which keep many arthropod species in check.

MIGRATION

While not all birds migrate, literally billions of individuals around the world fly great distances between summer and winter homes. Migration can also consist of short geographic distance between neighboring habitats. All migrating species face the challenges of successfully moving between, and surviving in a variety of habitats. This means adapting to different flora, predators, weather conditions, competitors, etc. many migrants spend months "fattening up" for lengthy, nearly non-stop journeys to distant destinations. Others require stops along the way in order to succeed, flying at night when predators are easier to avoid, and sheltering during the day when food is easier to find. For migrating birds, many habitats offer temporary shelter. Waterfowl, for example are required to follow waterways, or search for wetlands. Without these temporary resting/refueling places, the probability of success, and therefore survival, is severely reduced. This potentially high-risk strategy is balanced by the high-reward opportunities of having young born in the spring temperate zone where food is usually abundant.

THE SPECIAL THREAT TO SPECIES WITH LIMITED DISTRIBUTION

Contrasting the great migrations, many birds remain in one area year round. Some, like the tropical ant bird, spend their entire lives within 700 feet of where they were hatched. Many bird species are rare, living in only small isolated ranges, on islands, or closely tied to a particular environment due to specializations. Ant animal, birds included, tied to a limited geographic range runs an added species survival risk due to the vulnerability of a single or limited environment. Every child has heard of the Dodo bird. On its home island it was remarkably successful, but the dodo's extinction was swift once humans arrived. Direct human persecution is responsible for only a handful of bird extinctions however. The issues of habitat destruction and introduced species have taken a much greater toll. Many bird species have evolved on islands free from mammals, or with limited mammalian predators. These species have the additional vulnerabilities of limited defenses when humans intentionally, or more often accidentally, introduce species into island ecosystems. Introduced species may destroy indigenous species through direct predation, direct competition, or simply by ecosystem disruption. Many more species have disappeared due to this type of indirect, and often ignorant, human cause effect than through direct human persecution (i.e. over-hunting). Regardless of the cause, extinct is still extinct.

THREATS AND CONSERVATION

Understanding these effects of human activities is key to understanding the threats we pose to all species. Birds, because they migrate, often require resources far beyond that found in a given place or during a single season. A wetland, woodland, or grassland, which may house few species for much of the year, may be critical to a number of bird species, which live thousands of miles away for a short period each year. A habitat destroyed or disrupted in North America, may lead to the extinction of a species, which winters in South or Central America. That species may in turn have played a crucial role in the ecosystem of the winter habitat located thousands of miles away from the original destruction, magnifying the effect far beyond the original event. For many migrating bird species, we do not even know the site of their winter homes, much less their role in the local environments. We do know that in North America our forests and wetlands are constantly being cleared for human development, including the widespread replacement of natural ecosystems with crop monocultures. The pace of this kind of habitat destruction or disruption is currently often more rapid in developing countries.

Most people are aware of the threat that pesticides posed to birds through egg-shell weakening and direct poisoning. However many may not be aware that outside the US many countries still using DDT and other chemical pesticides banned in this country. Often, US chemical companies are still the suppliers.

Many people are also unaware of the devastation to wild bird populations caused by the pet trade. Far more birds die than ever make it to pet shops alive. For many years the US has been the world’s top importer of exotic parrots. A great many of them die after they get here. Three main reasons are: 1) the trauma of capture and transport; 2) buyers don’t know how to, or unable to, meet the special needs of the species; or 3) new pet owners, unaware of the difficulties and responsibilities of caring for an intelligent, non-domesticated species, give up and “release” the bird into a local habitat to which they are unsuited or disruptive. We can never over-emphasize the issues involved in keeping exotic birds as pets to the American consumer.

Birds have always been important symbols in human culture, but we all are still learning how important they have always been to our well-being. They are important components of every ecosystem humans occupy in ways we are still learning to appreciate. They act as natural control mechanism on many species of insects that we consider agricultural pests. The miner’s canary is a simple metaphor for how important they can be as indicators of environmental “health”. Birds are often very visible and occupy a high place in their food web, making them excellent indicator species. Watching them gives us a signal as to when we need to take a closer look into the condition of their environment. Their wide ranges provide a focus when studying how interrelated environmental issues are worldwide. Birds have also often been flagships species for conservation efforts. Many of the worlds most vocal naturalist, current and historic, have been birder’s.

Over 75 years ago, the US and Canada (through Great Britain) signed the Migratory Bird Treaty, which allowed for the recovery of many over-hunted populations. In the 1930s and 1940s the US bird conservation emphasis switched from limiting hunting to protecting habitat, as the Dust Bowl years highlighted the issue of human impact on the environment. In the 70s and 80s the Endangered Species Act focused attention on species in danger of immediate extinction. Unfortunately the number of animals in that category has only grown, with well over ten times the number of species listed now. Today we need to look at not only our own backyard (literally), but understand the issues for birds and other animals' worldwide. Like the canary carried into the mine, migratory birds act as indicators of inter-continental ecosystem health. Until we can begin to understand the enormous complexity of the ecosystems of the world we live in, we should look to them for clues.

How you can help make a difference in maintaining migratory bird populations:

What to buy or do	Why
• Buy shade coffee or sustainable coffee that is organic and fairly traded	• Increases tropical forest habitat for birds and other wildlife; conserves soil; provides fair profits for farmers; fewer pesticides in environment
• When buying produce from Latin America, such as bananas and pineapples, choose organic when available	• Reduces the amount of dangerous pesticide use in the tropics; fewer birds killed; safer for farmers and consumers
• Buy organic, or avoid altogether when possible, the North American crops that pose the greatest risk to birds: alfalfa, Brussels sprouts, blueberries, celery, corn, cotton, cranberries, potatoes, and wheat	• Reduces the amount of dangerous pesticides in the environment; fewer birds killed; safer for farmers and consumers
• Buy wood and paper products that are certified by the Forest Stewardship Council	• Increases amount of forest being logged sustainably and responsibly; better habitat for birds and a healthier forest
• Buy disposable paper products (toilet paper, paper towels, tissues) that are made from recycled paper and that are not bleached with chlorine	• Reduces logging pressure on forests; increases habitat for birds; creates less pollution
• Turn off the lights at night in city buildings and homes during peak migration periods	• Fewer birds killed and injured by hitting buildings; saves electricity
• Keep your cat indoors	• Fewer birds killed; healthier and longer lives for pets

From *"Silence of the Songbirds"* by Bridget Stutchbury

Bird Orders at the San Francisco Zoo (There are a total of 40 Bird Orders)

Struthioniformes: (ostrich) a ratite bird order
Rheiformes: (rheas) Neotropical flightless bird order
Casuariiformes: (emu and cassowary) a group of large, flightless birds that includes two families native to Australasia.
Sphenisciformes: (penguins) flightless birds comprising all existing penguins
Pelecaniformes: (pelicans) large waterbirds that have feet with all four toes webbed (totipalmate)
Ciconiiformes: (stork, hamerkop, ibis and spoonbill) large, long-legged wading birds with large bills
Phoenicopteriformes: (flamingos) large gregarious wading birds having a pink-and-red plumage and downward-bent bill
Anseriformes: (waterfowl, ducks, and swans) highly aquatic birds
Falconiformes: (falcons, eagles, hawks, and turkey vulture) diurnal birds of prey
Galliformes: (fowl, helmeted guinea fowl, chickens, turkey and currasow) heavy-bodied ground-feeding birds
Gruiformes: (cranes, crowned crane) birds with long legs, necks and beaks. Gruiformes have elaborate courtship rituals and form large flocks.
Columbiformes: (doves and pigeons) stout-bodied birds with short necks, and have short, slender bills with fleshy ceres
Psittaciformes: (parrots and macaws) characterized by curved beaks with the lower one fitting inside the larger upper beak when they are closed and their bright plumage.
Cuculiformes: (cuckoos, plantain-eater, and turacos) Birds in this order have bills that curve down and pointed wings and many are brood parasites
Strigiformes: (owls) mostly nocturnal predatory birds
Piciformes: (toucans & woodpeckers)
Coraciiformes: (kingfishers, hornbill, and kookaburra) colorful near passerine birds
Passeriformes: (passerines, perching birds, and starling) known as perching birds, includes more than half of all bird species

Sources: updated 12/99, 2006, 11/12, 11/13

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Bird Feather Types, Anatomy, and Molting

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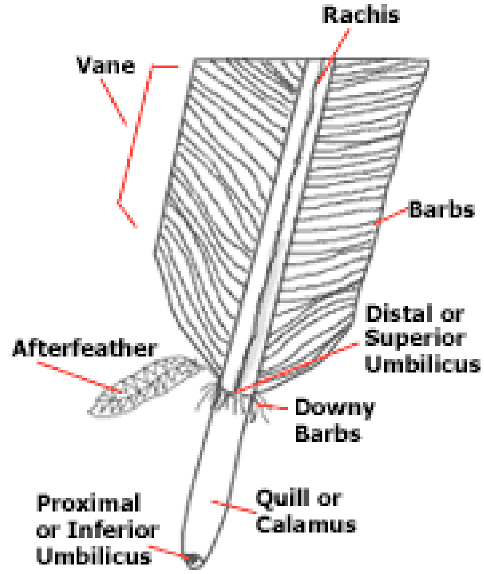
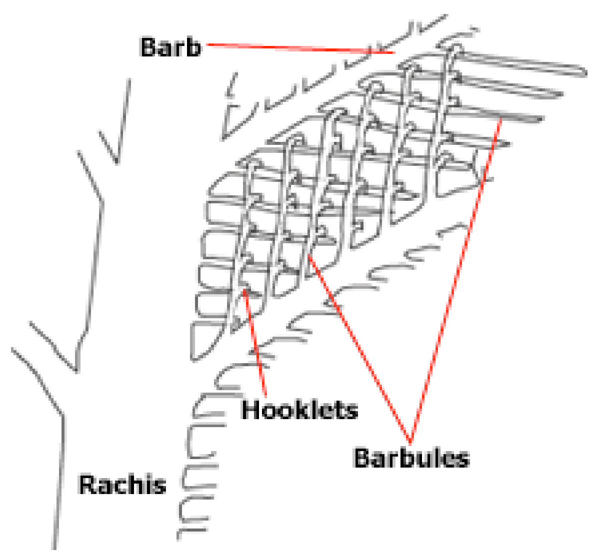
Feathers evolved from the scales of reptiles, and set birds apart from all other animals. Feathers are necessary for flight, insulation, and courtship displays. Feather colors and shapes help us distinguish between different species of birds and, in some cases, between males and females. Because feathers are so different, there are many different anatomical and technical terms used in their descriptions. This article will help you learn some of this terminology and understand more about these amazing adaptations.



Feather Anatomy

Feathers are made out of keratin, the same protein found in hair and nails. Feathers have a central shaft. The smooth, unpigmented base, which extends under the skin into the feather ***follicle***, is called the **calamus**. The portion above the skin, from which the smaller barbs or branches extend, is termed the **rachis** or **scapus**. On each side of the rachis there is a set of filaments, called **barbs**, which come off at approximately a 45º angle. This portion of the feather that has barbs is called the **vane**. In the larger feathers, these barbs have two sets of microscopic filaments called **barbules**. Barbules from one barb cross the adjacent barbs at a 90º angle. Barbules, in turn, have **hooklets**, sometimes called **hamuli** or **barbicels**, which hook the barbules together, like a zipper, forming a tight, smooth surface. These maintain the shape of the feather. Without these strong linkages, the feather would not be able to withstand the air resistance during flight. The barbs or hooklets may become separated from each other; if this occurs, the bird can reattach them while preening. At the base of the feathers, there are often barbs that are not hooked together. These are called **downy barbs**.

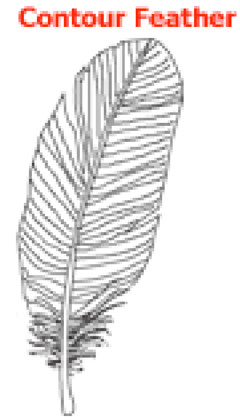


Feathers with barbules and hooklets are termed "**pennaceous**," and one can think of them as the feathers that would be used for a quill pen. Feathers without barbules and hooklets, such as down feathers, are called "**plumaceous**" and have more the appearance of a plume. Some feathers have both pennaceous and plumaceous portions. Some feathers have what are called **afterfeathers**, or **hypopenae**, at the base of the vane in an area called the **distal umbilicus**. These, really, are barbs without hooks, which help trap air and offer some insulation.

Feathers are not arranged haphazardly on the bird, but in major distinct tracts called **pterylae**. The featherless areas between the pterylae are called **apteria**.

Types of Feathers

As there are different types of hair on furred animals, birds have different kinds of feathers, each having a particular function. The types of feathers include:

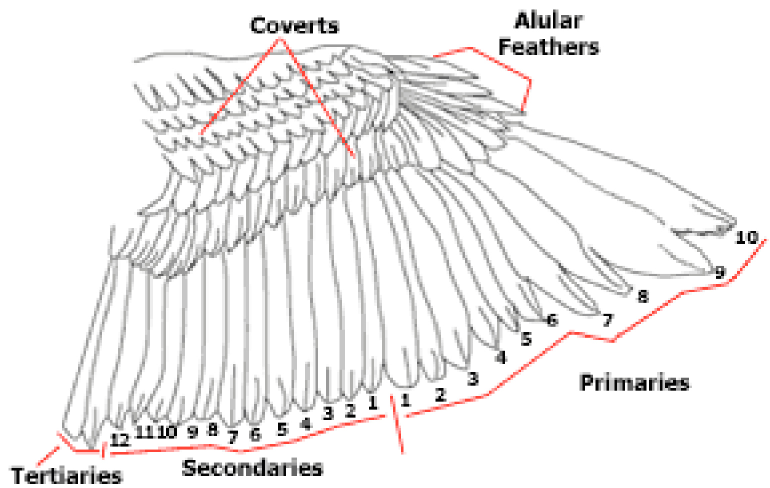


- Feathers with Vanes: Contour and Flight Feathers
- Down
- Filoplume
- Semiplume
- Bristle

Contour feathers: Contour feathers cover most of the surface of the bird, providing a smooth appearance. They protect the bird from sun, wind, rain, and injury. Often, these feathers are brightly colored and have different color patterns. Contour feathers are divided into flight feathers and those that cover the body.

Flight feathers: Flight feathers are the large feathers of the wing and tail. Flight feathers of the wing are collectively known as the **remiges**, and are separated into three groups.
The primaries attach to the metacarpal (wrist) and phalangeal (finger) bones at the far end of the wing and are responsible for forward thrust. There are usually 10 primaries and they are numbered from the inside out.
The secondaries attach to the ulna, a bone in the middle of the wing, and are necessary to supply "lift." They are also used in courtship displays. There are usually 10-14 secondaries and they are numbered from the outside in.

The flight feathers closest to the body are sometimes called **tertiaries**.

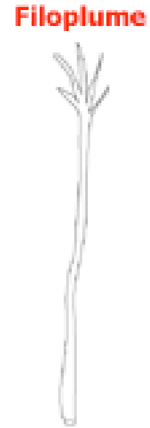


The tail feathers, called **retrices**, act as brakes and a rudder, controlling the orientation of the flight. Most birds have 12 tail feathers.

The bases of the flight feathers are covered with smaller contour feathers called **coverts**. There are several layers of coverts on the wing. Coverts also cover the ear.

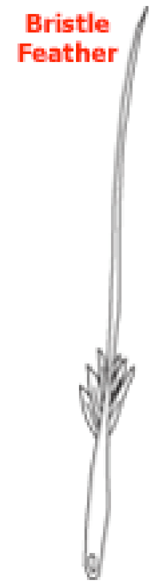
Down feathers: Down feathers are small, soft, fluffy, and are found under the contour feathers. They are plumaceous, and have many non-interlocking barbs, lacking the barbules and hooklets seen in contour and flight feathers. This makes it possible for them to trap air in an insulating layer next to the skin, protecting the bird from heat and cold. They are so efficient, humans use these feathers for insulation, too, in down jackets and comforters.

There are special types of downy feathers called **powder down feathers**. When the sheaths or barbs of these feathers disintegrate, they form a fine keratin powder, which the bird can spread over its feathers as a water-proofing agent. The powder also assists in cleaning as the bird preens. The absence of powder down in birds such as cockatoos and African greys can be a sign of disease, including beak and feather disease.



Filoplumes: Filoplumes are very fine, hair-like feathers, with a long shaft, and only a few barbs at their tips. They are located along all the pyterlae. Although their function is not well understood, they are thought to have a sensory function, possibly adjusting the position of the flight feathers in response to air pressure.

Semiplumes: Semiplumes provide form, aerodynamics, and insulation. They also play a role in courtship displays. They have a large rachis, but loose (plumaceous) vanes. They may occur along with contour feathers or in separate pterylae.



Bristle feathers: Bristle feathers have a stiff rachis with only a few barbs at the base. They are usually found on the head (around the eyelids, nares, and mouth). They are thought to have both a sensory and protective function.

Feather Growth

Like hair, feathers develop in a specialized area in the skin called a **follicle**. As a new feather develops, it has an artery and vein that extends up through the shaft and nourishes the feather. A feather at this stage is called a **blood feather**. Due to the color of the blood supply, the shaft of a blood feather will appear dark, whereas the shaft of an older, mature feather will be white. A blood feather has a larger quill (calamus) than a mature feather. A blood feather starts out with a waxy keratin sheath that protects it while it grows. When the feather is mature, the blood supply will recede and the waxy sheath will be removed by the bird.

Although an adult bird will typically replace all of its feathers during a molt, the loss of feathers is staggered, often over several months, so the bird has enough feathers for flight and insulation. A molt is usually triggered by the change in day length or may occur after breeding. Some wild birds, such as goldfinches, who molt twice a year, change from a bright plumage during the breeding season to a more somber plumage for the rest of the year.

Feather Color

Feather color is determined by the presence of various pigments, including melanins, carotenoids, and porphyrins.

- Melanins are brown to black pigments that are also found in mammals. In addition to adding color to the feather, melanins also make the feather denser and more resistant to wear and breakdown by sunlight.
- Carotenoids are generally yellow, orange, or red in color. They are synthesized in plants, and absorbed by the bird's digestive system, and then taken up by the cells of the follicle as the feather is developing.
- Porphyrins are red and green pigments that are produced by cells in the feather follicle.

The next time you look at a bird, you will be able to better understand how its feathers protect it and make it possible for the bird to fly. Down to the microscopic level, you can appreciate the complexity and specialization that make birds such a unique part of the animal kingdom.

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