

# Basic Avian Anatomy

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## Introduction

Everyone is familiar with the anatomy of mammals and may also have some knowledge of a few avian anatomical characteristics. The purpose of this discussion is to provide a deeper insight into avian anatomy and provide some comparisons to mammalian features. An understanding of avian anatomy is essential for avian practitioners. Sources of information for this discussion include the fine work of Dr. Howard Evans and Dr. Robert Clipsham.

## Feathers

Feathers are unique to birds. Birds grow feathers in and around eight well- defined feather tracts or pterylae; they are not haphazardly arranged. Feathers compromise from 10-20% of a bird's body weight. Each feather can be raised by a separate skin muscle ('raising their hackles' or fanning tail). Feathers are outgrowths of the feather follicles of the skin and are the counterpart to hairs and hair follicles in mammals. Feathers provide many functions for birds, attracts mate or deceives predator, heat control, flight, aerodynamic streamlining and water buoyancy.

Feathers are not really "bird hairs" but are probably modified scales passed down from their reptilian ancestors. Feathers can be grouped into three categories:

- 1) *Contour feathers* or penna – These feathers cover the body, wings and tail, and are the feathers most obviously visible on the bird.
- 2) *Down feathers* or plumules – These tiny, soft down feathers are found associated with contour feathers and/or the spaces between them.
- 3) *Tufted bristle feathers* or filoplumes- Feathers which are modified and appear as 'eyelashes and nose hairs.'

## Contour Feathers

The contour feather consists of a shaft with a vane. The vane-bearing segment is called the rachis and the non-vane portion is the calamus or quill. The opening at the tip of the quill is the pathway for blood vessels to feed the pulp of the developing feather. The vane on each side consists of rows of rami or barbs. This is a system of hooks and flanges on opposite sides of each barb that hook together like a Velcro™ strip so that the feathers can then hold strong rigid position. It is relocked every time a bird preens. Preening is essential to maintain a sleek appearance. Birds that are not preening normally (perhaps due to illness) will have a poor appearance to the feathers because they have not 'locked' the barbs and hooks. Ostriches do not have a well-developed system of barbs and hooks on the vanes of their feathers so that their contour feathers appear fluffy.

### Remiges (remix) - Flight feathers

The primary flight feathers are anchored in the pinion (“hand” equivalent) and their numbering begins from the wrist outward to the end of the wing. Parrots have between 9 to 11 primary flight feathers, 10 is the average. The secondary flight feathers arise from the forearm/ulna. The numbering begins from the wrist inward. Parrots have between 10-13 secondary flight feathers. Tertiary flight feathers arise from the upper arm or humerus. The alular remiges arise from the thumb remnant on wing (alula).

### Covert Feathers

Covert feathers are the smaller overlapping feathers that cover the quill of each flight feather. Each wing has primary, secondary and tertiary coverts, labeled according to location.

### Retrices (retrix) - Tail feathers

The tail feathers arise from the uropygium. They are intimately anchored to the end of the spine, as the remiges are to the wing skeleton. They are usually from 8 to 20 tail feathers, 12 generally. They act as rudders while bird is in flight. These feathers should never be clipped to restrict flight.

### Down Feathers

The down feathers have little or no quill. They do not possess barbules to interlock which produces their fluffy appearance. They are found along or between the feather tracts. Down feathers provide insulation for the bird. Sometimes they may be entirely missing. Powder down is special modification of the down feathers where the feathers themselves become very powdery as they develop, creating a powder that will cover the feathers. Cockatoos produce large amounts of powder down. It may act as a water repellent. Its absence can lead to dirty and damaged feathers.

### Bristle Feathers

These are highly modified feathers, lacking most or all of their barbs. They are mistakenly called hairs. These feathers possess highly innervated follicles and are very sensitive to pressure and vibration. They are thought to assist in preening, displaying and flight. Bristle feathers are found mostly on head, neck and eyelids.

### **Beak**

Upper and lower beaks are derived from hardened (keratinized) layers of skin and are attached to extensions of the skull bones. The cere gives rise to the beak. The beak covers a lightweight, well-vascularized network of tissues, including nerves. The beak grows constantly to replace wear. The superficial layers of the beak flake or wear off during normal beak activity and chewing. If a bird does not engage in enough beak activity due to the lack of proper chew toys or illness the beak can appear flaky or irregular, overgrows and must be trimmed. Normal, healthy birds do not require beak trimming.. Do not be fooled into thinking that an overgrown beak is merely due to ‘not using the cuttlebone.’ An overgrown or irregular appearing beak is not always due to lack of wear, quite often it serves to indicate a disease condition, such as fatty liver disease. Veterinarians should exercise caution whenever a bird comes in for a beak trim. Is it truly a grooming problem or a symptom of disease? Beak malocclusions are frequently seen in pet birds and can be caused by genetic abnormalities, trauma or disease. Occasionally these malocclusions can be surgically repaired. If they cannot be repaired, then periodic trimming may be necessary.

## **Claws**

The claws are hard, keratinized tissues overlying a core of softer tissue, blood vessels and nerves (like the beak). They grow constantly through the life of the bird. A variety of perch diameters and activity off the perch can aid in the wearing down of the nails. Cement perches are helpful in keeping the tips of the nails rounded. However, despite these measures, nail trims are frequently required with pet birds. Nails should be trimmed short enough to prevent breakage and subsequent hemorrhage but not so short that the bird may have difficulty grasping the perch.

## **Skin**

Avian skin is much thinner than that of mammals. There are skin thickenings at places of friction. Specialized skin structures can be present including combs, wattles, brood patches and leg scales. The blood supply to the skin is more delicate than mammals so special care must be taken during surgical procedures. Since the skin is protected by feathers, no special care is needed. Never apply any oil or grease to the skin or feathers.

## **Skin Glands**

There are no sebaceous (oil) or sweat glands present. The only surface gland is the oil gland also called the preening or uropygial gland, found at the base of tail. The gland, which secretes an oily material that is used during preening, is bi-lobed in appearance with a centrally located papilla. Quite often the papilla is encircled with a rim of feathers that acts as a wick when the secretion is produced from the gland. The uropygial gland is absent in some species. For example, it is not found in Amazons parrots and hyacinth macaws but it is very noticeable in parakeets and canaries. It may sometimes require surgical removal because it can abscess, become cystic, impacted or cancerous. Its absence causes no ill effects. This gland should be checked annually during the physical examination. If the bird is pecking excessively at the top of the tail there may be a problem with the gland.

## **Skeletal System**

Avian bones have the same basic composition as those of mammals. They are an organic lattice work of living tissue, reinforced with calcium phosphate and other minerals. Some bones are either solid or contain blood vessels and bone marrow (like mammals). The amount of marrow decreases as bird ages. Some bones are pneumatized (air-filled). This low bone density allows flight and water buoyancy. The air passages extend from the air sacs of the respiratory tract into the shafts and central portions of the pneumatized bones. Unfortunately this can also allow respiratory tract infections to settle in the bones and cause osteomyelitis.

### Pneumatic bones:

- |                             |                            |
|-----------------------------|----------------------------|
| -ileum/pubis (pelvis)       | -sternum (keelbone)        |
| -humerus (upper wing)       | -clavicle (wishbone)       |
| -vertebral bones (backbone) | -coracoid (shoulder strut) |
| -skull                      |                            |

### Endosteal bone formation (hyperostosis)

Hormones influence the system of egg-laying hens to deposit extra calcium within certain long bones. This ensures an adequate supply of calcium for eggshell formation. That is why calcium supplementation is so important for breeding birds. Endosteal bone formation (also termed hyperostosis) offers the avian practitioner clues diagnostically. This is especially helpful when a female is presented with abdominal

enlargement. If a female bird is being evaluated radiographically and endosteal bone formation is noted, it indicates hormonal activity. Even though abdominal structures might not be easily distinguished on the radiographs, this finding directs the diagnostic process to the reproductive tract. A normal reproductive cycle, ovarian cysts or ovarian tumors might be potential reasons for abdominal enlargement coupled with endosteal bone formation. If a known male bird displays endosteal bone formation, a likely cause would be a testicular tumor with resultant feminizing due to secretion of female hormone by the tumor.

### Bones of the head

The walls of the avian skull are much thinner than that of mammals. They are more prone to concussions and brain damage. The upper beak is not a bone but is an outgrowth of thickened skin. The upper jawbone attachment to skull is hinged so that the upper beak has a range of movement.

### Vertebral Column

It is composed of many small bones linked with ligaments. Birds possess a strong and flexible backbone. It supports the head and provides for a wide range of neck movement. Because birds do not possess well developed muscles for eyeball movement they rely on their ability to maneuver their head and neck for good visualization of objects.

The number of bones in the backbone are:

mammals- cervical 7- thoracic 13- lumbar 7- sacral 5- coccygeal (variable)

chicken- cervical 14- thoracic 7- lumbar/sacral 14- coccygeal 6

### Synsacrum

Evolution has resulted in the fusion of many vertebrae in birds to decrease flight stress and wind resistance. The fusion of the last two thoracic/lumbar/sacral and first few coccygeal vertebrae is called the synsacrum. This complex is firmly joined to the pelvis and provides stability for flight.

### Pygostyle

The last few coccygeal fuse to form the pygostyle which acts as anchor for the main tail feathers. With some fractures or damage to the pygostyle, a male bird may be unable to successfully copulate with a hen.

### Wings

The humerus is pneumatized with the clavicular air sac (near the shoulder). In the forearm the ulna is the major (larger) bone, in mammals it is the radius. The wrist is fused with the hand to form a single unit, carpometacarpus. Movement is sacrificed for flight stability. Only a few finger digits remain, with the alula representing the remnant of the thumb.

### Legs/Feet

The thigh is similar to that of mammals. The tibiotarsus is the largest bone in the leg and is produced by the fusion of the shin bones and the tibia with the tarsal bones. The fibula is the small sharp bone in drumsticks. The bones in the feet have fused to form the tarsometatarsal bone. Birds have a variable number of toes. Pet birds have four toes on each foot. The psittacine birds have their toes arranged with two directed forward and two back (zygodactyl), this facilitates their grasping and climbing activities. The other non-psittacine pet birds (such as canaries, finches, mynahs, toucans) have three toes directed forward and one back (anisodactyl). Other toe configurations occur in other types of birds.

## **Nervous System**

### Brain

The avian brain is evolutionarily between mammals and reptiles. Mammals have a well-developed cortex, possessing gray matter which is used for higher reasoning, abstract thought and highly involved intellectual processes. The cortex is the most recent evolutionary development in the mammalian brain. The avian brain entirely lacks this region. It is believed that birds tend to function largely on instinctual and behavioral level. The capacity for rational learning ability has been retarded on an anatomical basis. It is suspected that the center for rational learning is in the area termed the basal ganglia. However, people that have birds realize that no matter what the scientists and anatomists say, birds seem to be capable of rational, cognitive thought and are highly intelligent.

### Eye

The optic lobes of the brain are large and well-developed, as sight is crucial to survival. The eyes are unusually large in birds, comprising 1/30 of body weight (dogs- 1/5,000 to 1/8,000). The vision of raptors (hawks and eagles) is 2-4 times more acute than man. The avian eye is no more accurate than man's, but the brain interprets visual images faster. The eye placement on the sides of the head increases field of vision (pigeon- avg. 300 degrees). They have poor depth perception, so they must constantly cock their heads to perceive objects from various angles to obtain accurate idea of location. Predatory birds (raptors) have eye placement similar to humans which enables excellent depth perception, essential for their hunting of prey. Birds do not have well-developed eye muscles and have limited eyeball movement, but have longer, more flexible necks so that the head moves more freely (owls can rotate the head 180 degrees). There are small bony plates inside the eye (sclerotic ring) to provide rigidity (avg. 12). The skeletal muscle in the iris allows voluntary control. That is why when a bird becomes excited, it can constrict its pupil at will. Rods for black and white vision outnumber cones for color vision in the retina of nocturnal birds, facilitating night vision with little color vision. The opposite is true in birds more active in daylight. Birds see color and do display definite color preferences. The third eyelid (nictitating membrane), which frequently passes over the eye, lubricates and protects eye.

### Ear

Most birds hear well and their ability is similar to that of man. There is no external ear flap (pinna).

### Sense of Smell

Birds possess a poorer sense of smell than man. Pet birds do, however, show definite responses to smell, especially when their favorite foods are being cooked.

### Taste

There are approximately 350 tastebuds in a parrot (man has 9,000). They are mostly in back of throat and base of the tongue. Vision plays a key role in food selection. Notice how a bird will look very skeptically at new food placed in the cage. Color, shape, size, and texture take priority over taste. Birds can differentiate sweet, sour, bitter and salty tastes.

## **Respiratory Tract**

Birds possess the most efficient respiratory system of all vertebrate animals. There are several differences from the mammalian system. Birds lack vocal cords, rather they vocalize with a muscular structure found at the bifurcation of the trachea, termed the syrinx. There are complete tracheal rings comprising the windpipe (not c-shaped as in man). This provides better protection for the bird trachea which needs to

move freely subcutaneously due to the long cervical region and the ability of the bird to twist the neck through a wide range of motion. Birds possess a series of air sacs (not present in mammals) to facilitate respiration, in addition to lungs. The lungs are small, compact and non-expandable as the air sacs do the expansion and contraction for respiration, while the key role of the lungs is for gas exchange. Only vestigial remnants of a diaphragm exist as it is not needed for respiration in birds. Free movement of the sternum is essential for respiration facilitating the expansion and contraction of the air sacs. If the sternal movement is restricted, the bird would suffocate.

### Upper Respiratory Tract

It consists of the nares (nostrils), nasal cavity, sinuses, oropharynx (throat) and trachea (windpipe). Avian sinuses are not enclosed in skull bone, but are surrounded by skin, fat and other soft tissues. They may be extensive and tortuous with limited drainage. The sinuses communicate with the lower respiratory tract and air sacs via channels in the neck. Some birds never get over stuffy nose or swollen eye conditions because the offending agent cannot be reached or may continue to reappear via some hidden area into an air passage.

### Lower Respiratory Tract

This consists of the syrinx (voice box), bronchi, parabronchi, and air sacs.

#### *Syrinx*

The syrinx is unique to birds. It lies at point where trachea divides to enter each lung. The syrinx is for vocalization, but does not contain vocal cords. It is a well-developed muscular structure. There can be accumulation of debris and infection at this site because of natural air flow reduction through the narrowed passage. Fungal growths (*Aspergillus* species.) and other infections are common at this site. Growths there are life threatening unless removed.

#### *Lungs*

The lungs are compactly fit against dorsal wall of thorax and they do not expand or contract. The lungs consist of tertiary bronchi (parabronchi) which are minute parallel tubes. There are 300-500 parabronchi per lung in chickens, 1800-2000 per lung in pigeons. They are visible radiographically as dark circles throughout the lung fields. Disease conditions that cause increased density in the lungs or congestion can lead to the disappearance of the parabronchi on the radiograph, which serves as an aid in the diagnosis of lung disease. The thin walls of the parabronchi have openings with tiny branching air capillaries that are intimately surrounded by blood capillaries for exchange of oxygen. Birds have an efficient one way flow of air through the lungs, not the in/out system found in mammals.

#### *Air Sacs*

Air sacs are another unique feature to birds. Most birds have four paired air sacs plus a single unpaired sac for a total of nine. The air sacs are membranous, thin walled (a few cells thick), lack major blood vessels and do not communicate except through primary orifices to the lung. Some air sacs extend into pneumatic bones.

#### *Air Sac Functions*

Air sacs perform several functions including; acting as air reservoirs by holding and expelling air, controlling body heat (through evaporation cooling), moistening air, cushioning the subcutaneous body layer, providing buoyancy, aiding some birds with vocalization and assisting courtship displays.

### *Avian Respiratory Cycle*

Two inspirations (inhalations) and two expirations (exhalations) are necessary for one breath to enter and exit the bird. With the first inhalation, air passes through the nostrils, nasal cavity, trachea, and into paired bronchi. Fifty per cent of the inspired air goes THROUGH the lungs and into the caudal set of air sacs. The remaining 50 % moves into the lungs. Upon the first expiration, lungs fill with air from the caudal air sacs. The air from the lungs and cranial air sacs empties through the trachea. With the next inspiration the stale air (the remaining 50% from the first inspiration) empties from the lungs into the cranial air sacs. Upon the next expiration, the cranial air sacs expel air out of the body. Thus, it takes two complete inhalation/exhalation cycles for a breath to travel through the bird. It should be noted that this allows for a one way flow of air through the lungs providing for efficient exchange of oxygen with the blood.

### **Digestive tract**

Birds have a single body chamber and do not have separation of abdomen and thorax as in mammals (separated by the diaphragm). Avian abdominal organs rest against the respiratory system freely. They are attached to each other by sheets and strands of connective tissue that allow for some limited movement of these organs. There are multiple 'cavities' that play a role during surgical or laparoscopic procedures. These are; the right and left pleural cavities, pericardial cavity, right and left ventral hepatic peritoneal cavity, right and left dorsal hepatic peritoneal cavity, and intestinal peritoneal cavity.

### Oral Cavity

Teeth are absent in all birds and replaced functionally by the cutting edge, tomia, of the horny beak. Ridges of the palate are used to hull seeds, and lateral grooves of the palate are used to crush food. Foods are mixed with saliva from salivary glands found behind the tongue and throughout mouth. The saliva moistens food as it is swallowed, however, as there are no enzymes present, no food breakdown occurs. When food is small enough, the tongue pushes it back into throat where automatic swallowing reflexes move it into the esophagus.

### Esophagus/Crop

The esophagus runs along right side of neck. It is important to know the position for tube feeding and hand-feeding. The esophagus enlarges at the base of the neck to form the crop (ingluvies). The crop is a widening of the esophagus and mainly serves as a storage chamber for food. It is not present in all birds (gulls and penguins, for example). The crop allows the bird to eat large amounts of food and digest it slowly over time. The crop, in psittacines, is oriented transversely across the neck, when distended will hang over the breast muscles.

### Proventriculus

The food leaving the crop re-enters the esophagus and then passes to the first portion of the stomach termed the proventriculus. This is the glandular portion, where many small acid-producing glands, that secrete gastric juice and begin the digestive process, are found in the wall. It is located just left of midline beneath the caudal portion of the keelbone.

### Ventriculus (Gizzard)

The food then moves from the proventriculus into the muscular ventriculus. Lying between the proventriculus and ventriculus is the intermediate zone. The thick walls of the ventriculus are essential for grinding food. Grit is stored here, as an aid to the grinding of the food. The ventriculus has a hardened membrane, the cuticle (koilin layer), which is continually worn from the grinding movements of the

organ. Avian species that eat only soft foods (such as lories) will have a ventriculus that is loose and thin-walled. A tissue fold at the base of the ventriculus holds food until ready to enter intestines. The pyloric fold prevents solid objects from entering intestine. The ventriculus is positioned to the left of the midline and occasionally can be palpated as a firm mass in the abdomen.

Ventriculus position is a helpful diagnostic tool, especially radiographically. The ventriculus is easily located on a plain film radiograph as it usually contains grit which will appear as a collection of mineral densities. The normal position is to the left of the midline near the left acetabulum. If the ventriculus is displaced caudally, it could be due to an enlarged liver, gonadal enlargement or enlargement of the cranial portion of the kidney. The ventriculus may be pushed cranially due to a renal enlargement, especially of the caudal renal portions, or if it is a female bird, possibly due to oviduct enlargement. Renal tumors also tend to push the ventriculus toward the ventral abdominal wall. When performing abdominal palpation on a bird, and the ventriculus is unusually prominent, there may be a mass or enlargement in the dorsal abdomen pushing the ventriculus ventrally.

### Intestines

The intestines possess the same anatomical divisions as in mammals, the duodenum, ileum and jejunum, although not as visibly distinct. This continues the digestive process by secreting digestive enzymes from the pancreas, which helps to break down the food. Most absorption of nutrients occurs in the small intestine. Paired ceca, which are prominent in chickens and other birds, are notably absent in most pet birds. The large intestine is very short (basically the rectum). In the large intestine, water is reabsorbed, which prevents dehydration.

### Cloaca

The cloaca is a common chamber for digestive, urinary and reproductive tract products. It is unique to birds and reptiles. The external orifice is called the vent. There are three internal compartments in the cloaca; the coprodeum (the most cranial), the urodeum, and finally, the proctodeum. Food passage from mouth to cloaca is about 3 hours for a parrot. This time is decreased by high water content or disease and is increased by decreased water or obstruction. The droppings vary in appearance by what products were mixed.

### Bursa of Fabricius

The bursa of Fabricius is the source of the B-lymphocytes. The bursa is an off-white, fleshy structure located on the dorsal surface of the cloaca. It is prominent in baby birds, but disappears as the bird ages, similar to what occurs to the thymus gland. If performing a necropsy on a young bird, it is important to locate the bursa and submit it for histopathology as it plays a key role in the immune status of birds. In psittacines, complete involution of the bursa may take 18-20 months, so this tissue should be submitted if identified in birds up to 2 years of age.

### **Liver**

The liver performs numerous physical, physiological and immunologic functions in pet birds. It comprises a greater percentage of body weight in a bird compared to man. In some birds, such as pigeons, the liver can normally be quite large. When performing abdominal palpation, the liver is normally not detectable. An enlarged liver is palpable, as it usually protrudes beyond the caudal border of the keelbone. In young birds, the liver may be visible through the skin. The liver plays a crucial role in the defense against disease and often a bird that is ill will have an enlarged liver, elevated liver enzymes and icteric serum.

Perhaps the significant direct involvement that the liver plays in avian disease is due to the fact that birds do not possess definite lymph nodes, rather they possess patches of lymphoid tissue, so that the role of the liver is enhanced.

### **Spleen**

The spleen is also essential in the bird's defense against infection. It is composed of lymphoid tissue (like a lymph node) and as birds do not possess organized lymph nodes the spleen must play an important role. The spleen is normally round in psittacines and elongated in passerines (canaries and finches). It can become tremendously enlarged when stimulated by demand for antibodies against infections or in a condition such as avian leukosis.

### **Kidneys**

The kidneys are found within bony depressions of the avian synsacral bone (renal fossae) on either side of spine. Each kidney has three divisions. There are many vessels and nerves (especially the sciatic) which pass through the substance of the kidney, preventing surgical removal of malignancies or performance of kidney transplants. Enlargement of the kidney can put pressure on the sciatic nerve causing paresis or paralysis in a leg, as seen with renal tumors in budgies. The kidneys are responsible for elimination of protein metabolic wastes produced daily, as in mammals. The avian kidneys are termed metanephric, evolutionarily between mammals and reptiles, consisting of a combination of mammalian and reptilian nephrons. The excretion, produced as the end product of nitrogen metabolism, is a pasty slurry of uric acid, not the ammonia (urea) of mammals. This leads to conservation of water and certain biochemicals. The wastes are carried by the ureters directly to the cloaca. There is no bladder or urethra present.

### **Heart**

The heart is similar in shape and construction to the mammalian heart. It is relatively larger due to greater metabolic needs. There are four chambers (2 atria, 2 ventricles). The avian heart beats quite rapidly as the smaller the bird the faster the heart rate. Small bodies have greater surface areas to volume, so they lose heat faster. The heart rate of the hummingbird is 500bpm at rest, 1200bpm during exercise; other rates are the canary 795bpm, chicken 350bpm and ostrich 175bpm.

### **Reproductive Tract**

#### Female

In female psittacines only the left ovary is functional. Birds of prey and the kiwi have a right ovary. An inactive ovary is miniature, somewhat triangular shaped with white follicular material present. An immature ovary could be mistaken for the adrenal gland or vice versa. An active ovary can be quite large, containing numerous follicles. In cockatoos, some macaws and some conures, the ovary will be black (melanistic). The oviduct is a single tubular structure divided into 5 parts. The proximal portion is the infundibulum, which receives the ovum and where fertilization occurs. The magnum is the largest part and secretes mucin/albumin to cover the ovum. The third portion is the isthmus, which is a non-glandular connection. The uterus, or shell gland is the fourth region and covers the egg with shell and pigment if present. The final portion is the vagina which connects to cloaca, receives and may store the semen.

#### Male

Male birds possess internal paired testes, epididymis, ductus deferens, and in some species, a phallus. The testes vary in color from white, yellow to brown or black in cockatoos. The testes vary in size according to breeding state; immature testes are extremely small, while a bird in breeding condition will have

immense testes. When out of season, they will reduce to a smaller size, but never as small as immature testes.

### **Review Avian vs. Mammals**

#### Birds

- feathers
- no sweat or sebaceous glands
- urophygial gland
- pneumatic bones
- long neck (c. 14-16)
- vertebral regions fused
- ulna bigger than radius
- pygostyle present
- crop usually present
- rudimentary diaphragm
- lack teeth
- cloaca present
- two portions to stomach
- no mammary glands
- lack bladder
- testes internal
- all egg laying
- true penis lacking
- air sacs present
- breathing by movement of ribs & sternum
- vocal cord absent
- syrinx for sound production
- nucleated erythrocytes
- no defined lymph nodes

#### Mammals

- hair present
- sweat/sebaceous glands present
- no uropygial gland
- no pneumatic bones
- shorter neck (c. 7)
- vertebral regions not fused
- radius bigger than ulna
- no pygostyle
- no crop
- functional diaphragm
- teeth present
- no cloaca
- single glandular stomach
- mammary glands present
- bladder present
- testes external
- platypus only egg laying mammal
- penis present
- no air sacs
- breathing via lungs & diaphragm
- vocal cords present
- no syrinx
- no nuclei in erythrocytes
- lymph nodes present

### **Conclusion**

Hopefully this basic overview will prove useful in the understanding of avian anatomy.

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