How Birds Have Come Into Existence.

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Abstract

In particular, this paper deals with the lineage of birds, and how it may be possible to trace them back to their origin which appears to be from Dinosaurs (esp. Therapods). This paper is an application of tracing various lineages in the fossil record. The idea is that if we can find small changes with each successive form, then we can show their descent with modifications. Of most importance is Archaeopteryx which was discovered only a few years after Darwin first published his ideas on evolution. It sparked people to believe that birds may be the direct descendants of dinosaurs. Since then, many other intermediates have been found to support this theory. We will look at related structures, and we will formulate the possible related behaviors based on what can be seen in the fossil record. Also, we will look at possible throwbacks to possible ancestral forms in chickens. We will look at an experiment that uses DNA as a molecular clock to see how long birds have been around. Finally we will look at possible intermediates, and come to a conclusion as to the Origin of Birds.
Birds are the direct descendants of dinosaurs. This has been debated for many years. There have been many sources of evidence which point to this conclusion. Birds are a monophyletic group with one common ancestor. There are many sources proving that birds had their origins in small theropod dinosaurs, also known as dromaeosarids. There are many intermediates which have been found with characteristics similar to that of dinosaurs and birds. The finding of the fossil of *Archaeopteryx* has intrigued scientists and stimulated a search for other potential intermediates. Because the fossil record is inconclusive in its evidence, some people have argued that birds did not evolve from dinosaurs but rather from mammals, pterosaurs, and crocodiles. Then, if birds did not come from dinosaurs how did they arise? We will examine various lines of evidence suggesting that dinosaurs are the predecessors of birds.

**Unique features of birds and dromaeosaurid theropods**

What is it that makes a bird a bird? The following are features inherent in all birds. First of all, the skull, according to Feduccia, “has single occipital condyle and movable quadrate, which articulates with the lower jaw. It [avian skull] has the form of cranial kinesis-movement of all or part of the upper jaw relative to the braincase.” *(Feduccia 1996: 5a).* This allows the jaw of the bird to move most efficiently. This braincase is fused and enlarged. Another feature, according to Feduccia, is a compact body. For example, “the wing has three instead of the normal five fingers of the vertebrate hand...secondary flight feathers emerge *(Feduccia 1996: 5b).* The wishbone, a prominent feature in the birds, has “clavicles which are fused to form the wishbone...this serves as a site for the attachment of the pectoralis flight muscles that power the downstroke of the wing in flight *(Feduccia 1998: 8).* Though flight is not a feature in all birds, it is a common feature in a majority of them. One other feature includes respiratory turbinites. These are “epithelially lined, scroll-like, ossified or cartilaginous structures located in the anterior passages of all extant birds and mammals. They act as intermittent heat exchanges which allow a high lung ventilation.” *(Ruben 1996: 1205)* They also have pneumatic bones, which have “openings in the wall of the bone for the airs sacs to enter the internal bone cavities.” This is another characteristic which allows air flow through the apparatus of the bird. This would provide...
a light structure necessary for flight (Fastovsky 1996: 296). Another detail is its warmbloodedness.

Flight is one feature apparent in most birds. For an organism to fly, it should have a small and light body. A light body would be the result of a light skeletal system which normally comprises the bulk of the weight of a body. Accompanying the modification of the bone structure, came the light body weight. “The major bones are hollow and pneumatized [contain an air sac], with direct connections to an extensive air-sac and respirator system. Many bones of modern birds have also been fused or deleted, more than in any other group of living vertebrate; these adaptations of lightening the body allow for flight.” (Feduccia 1996: 5)

Feathers are important structures important for flight. Feathers first came about most likely for insulation. According to Feduccia (1980: 53), they were developed in order to keep the animal warm. Strongly asymmetric vanes are found in feathers, and “as a result of their asymmetry, flight feathers have an airfoil cross section” (Feduccia 1980: 52a) This air foil is what suggests that they are important aerodynamically for producing lift. The Archaeopteryx’s feather, found in 1861, is asymmetric, which shows that it most likely could fly (Feduccia 1980: 52b). Even though the Archaeopteryx did look very much like a reptile, it has that special feather design which makes us believe that it could fly in a bird-like manner. Due to the fact that feathers are such complex structures, we can make the assumption that feathers evolved only once. Therefore, birds, being only the feathered animals must have had a common ancestor and birds are a monophyletic group on the basis of feathers.

Besides insulation, another adaptive reason for how birds could have acquired feathers is by fighting and display. “Successful display was increased by lengthening the arms, especially the hand, and by actively waving them, perhaps waving them vigorously. Flapping in this display would have encouraged the evolution of powerful pectoral muscles."(Rowe 1995) Display could have been used in two possible purposes. The first being mating rituals. The second being a threatening display as to display avoid a flight. When threatening display was not enough to ward off fighting, the birds would end up in combat, which would have been the last resort. The claws on the wings were used as weapons, although modern birds do not possess claws on their wings. The wings are “still used as weapons in forward and downwardsmashes."(Rowe 1995) This characteristic has been found in the theropod dinosaur, Velociraptor. The stroke used in flying is
very similar to that used in fighting. As the blows became quicker, they became more effective in battle. “This would rapidly encourage an effective wing-lifting motion that minimized air resistance, so the wing action would almost be identical to a takeoff stroke.”(Rowe 1995)

Another of the most vital features which allow birds to fly is the wishbone. “To do more than glide, Archaeopteryx needed not only its aerodynamic feathers but a skeletal architecture that would allow its muscles to produce the powerful flapping” (Feduccia 1980: 57). The function of the wishbone (furcula) is in the attachment of powerful flight muscles to the bone. The furcula, according to Fastovsky (1996: 297), would then attach to the coracoids and shoulder joint, where it would attach to the wing. If it was not a strong bone, the powerful muscles might break the bones, or simply not allow the animal to fly. Because this bone was present in the Archaeopteryx as well as in modern birds, we can say that they are possibly related to each other.

If the birds descended from dinosaurs, were the dinosaurs themselves actually warmblooded? Endothermy, according to Fastovsky, (1996: 329), is a way by which warm blooded organisms regulate their energy. It is an efficient method, in which the body is able to internally regulate their temperatures. He further notes that endothermic organisms, as compared with ectothermic organisms (cold blooded organisms), are able to increase their oxygen consumption exponentially. This would therefore allow it to utilize their metabolic functions more efficiently. This would allow warmblooded animals to have a higher level of activity as compared with coldblooded organisms. On the assumption that walking speeds could be inferred by track marks, according to Fastovsky (1996:334-35), it has been found that therapod dinosaurs had speeds equal to or even greater than that of present day mammals. Given the amount of energy required for such activity, it could therefore conclude that these dinosaurs were warmblooded organisms.

Therapods have been seen to be more than an intermediate, but the true ancestors of birds. These dinosaurs were bipedal. They, according to Fastovsky (306-308), had hollow bones, as well as a foot composed of three primary digits, both features also found in birds. Having hollow bones, allowed dinosaurs to potentially leap out at their opponents, because of the less added weight. This decrease in weight would have allowed these dinosaurs to run faster after/from their opponents. Also found in the in theropods is a “moon-shaped bone” in the wrist which is found in the birds of today. (British Museum of Natural History 1979: 49)
What is it that distinguishes a dromaeosaurid dinosaur? These theropod dinosaurs possess several significant features. One feature, according to Fastovsky (1996: 278), is that they were often small in size, they walked on their hind feet, they had “sickle-like claws on their feet, and they had teeth.” They also possess a furcula (or wishbone), a common feature in birds. Another feature, according to Thorn Holz Jr. (1997a), is that Dromaeosaurids have a set of bones that lie in rows on the dorsal side of the rib cage. This would have allowed the contraction of shoulder and arm muscles. He notes how this feature is useful in grasping and in a flying-like motion. Another significant feature, according to Holz (1997b), is that they have been seen to have folding arms. This feature may have allowed these organisms to have less resistance in moving about and therefore, move faster.

Archaeopteryx and other intermediates

Dromaeosaurid dinosaurs possess many features which show how they potentially could have evolved into modern birds. These theropod dinosaurs provide a sufficient foundation for the Class Aves. According to Malcolm Browne, the *Velociraptor* was found to possess a wishbone (Browne 1997: 14). There are many other intermediates found in the evolutionary steps to birds from dinosaurs; in each successive step, the intermediates are closer to the modern bird.

There is a considerable amount of evidence which show that dinosaurs watched the eggs and took care of the youth like modern birds, as seen in fossils of dinosaurs with their eggs and dinosaur nestling. This evidence is clearly shown in a fossil in the Gobi desert; it was a nest of eggs beneath the bones. The *Oviraptor* dinosaur, an ostrich-size theropod, was protecting its eggs. “Its legs tucked carefully under the body and its arms curled around the perimeter of the nest, just like a barnyard chicken.” (Lemonick 1996: 62a). According to Mark Norell, a leader of the U.S.-Mongolian joint expedition, “This fossil demonstrates that brooding behavior evolved long before there were birds.” (Lemonick 1996: 62b). Like dromaeosaurs and birds, it had a wishbone and the bird characteristic of not having teeth (Fastovsky 1996: 389-90).

An important intermediate has been found with many more birdlike features. Though the organism, *Unenlagia* was a theropod, it looks very birdlike. According to Laura Tangley (1997: 14), it has a pelvis which resembles a cross between a dinosaur’s and birds’s and it has a shoulder which “not only did allow the animal to move its short arms forward” but it allowed for the “up-and-down flapping motion.” This finding therefore demonstrates how this may be one step along
The evolutionary scheme of how birds evolved.

The **Archaeopteryx** is still a major piece of evidence in the lineage between dinosaurs and birds. It is often represented as the first bird. It has been found to be an intermediate because it has many features present in both birds and dinosaurs. First of all, it had the dinosaurian characters of teeth, claws, and a tail. Though it had teeth according to Thomas Holz (1997a), they were reduced in number and unserrated. Serrations are a common feature found in theropods and other dinosaurs. This proves that Archaeopteryx was losing its ancestral characteristics. Holz further notes how the vertebrae of the tail were smaller in number, as compared with theropods and was more birdlike. It was found to have feathers, a clear indication of being like birds. It also had the birdlike feature, according to Feduccia (1996:32a), of a sternum and a wishbone or furcula. Accompanying this was an enlarged coracoid bone, which allows for the attachment of flight muscles. Another clear indication that it was more birdlike is that, according to Feduccia, the foot bones, and the metatarsals were partly fused (Feduccia 1994:32b). Holz (1997b) points out that it had an enlarged brain and the bones of the cranium were fused; a clear indication it was moving away from its dinosaur ancestors.

Archaeopteryx, however, is not the only dinosaur-like bird found. It was the famous fossil discovered in London that provided some important support for which proved that the **Archaeopteryx** could be the direct ancestor of birds. It stimulated the search for other intermediates. In order to be considered intermediates these animals had to possess similar characteristics to **Archaeopteryx** with small changes leading to birds. Allowing the descent of dinosaurs to be traced, many other intermediates have been found which provide additional links between birds and dinosaurs.

Another similar specimen found in the Gobi Desert, known as **Mononykus olecranus**, is a another member or the bird class, but is it? According to Mark Norell, it has been found to have stubby upper arms and even stubbier forearms that each ended in a single, powerful hooking claw.” This is a prominent feature found in theropods. Another feature is the “keel- a prominent ridge that extends forward from the breastbone.” It also had feathers.(Svetel 1994: 51) Did flight really evolve from this organism? Though it had the structures associated with flight, this may have been a rudimentary feature. Because it did not have wings, it could not fly. So, was this a dinosaur or a bird? It seems to be another potential intermediate ever closer to birds. This may be
proof to to how flightless birds may have evolved, or it may be a precursor to flight.

One group of organisms, the Enantiornithines represent more intermediates. It represents an even closer ancestor to birds, These organisms, referred to as “opposite birds”, had according to Feduccia 1996: 142) wings that were uniform, they were”powered fliers”, and they had a sternum. The wings and sternum exhibit that it was very birdlike. However, it has a pubis bone which is oriented opposite as that as compared with birds, which is a common feature in many dinosaurs.

There list of Enantiornithines is extensive. Sinornis clearly shows that its structure is closer to birds than that of the Archaeopteryx. For example, “the body is shortened” and it had a modern wrist joint common to many modern birds and dinosaurs which allowed the “the wing to fold tightly against the body. It also has a large sternum,” which indicates that it was capable of “powered flight.” Yet, unlike any bird and like its ancestors, “Sinornis had teeth and it had an unfused hand.” (Fastovsky 1996: 314)

“In both the Archaeopteryx and in the lower Cretaceous Enantiornithine Cathayornis, the premaxilla ..bears four teeth. Maxillary teeth were retained by early other avians from other dinosaurian predecessors but were lost in the Enantiornithine (Sanz et: 1543). However, there have been features found which in fact show how these intermediates are similar to birds. According to Feduccia (1996: 152), since it had a well developed sternum, it was able to fly. He further notes that it had a hooked beak, a common feature of many present day birds.

Another enantiornithine found, Confuciousnoris, has a “small unkeeled sternum” [which points out it was not equipped for powered flight] present and like Archaeopteryx, it had a similar foot and recurved pedal claws, the plumage showed a tail with contour feathers, but unlike Archaeopteryx, its metatarsals are fused proximally and a fifth metatarsal is apparent.”(Hou 1996: 1164). This fusion is a characteristic showing how this intermediate looks more like birds. Also, like birds, its tail bones are fused into a pygostyle. (Hou 1996: 1164). The pygostyle, a fused tail, is a feature found inherently in birds. Though it has some ancestral characteristics, it is looking more like birds.

Another specimen found, quite distinct from Confuciousnoris is the Enantiornithine, Liaoningornis. It was distinct because it has “a keeled sternum, the bones of the torsometarsus were fused, the sternum is long and broad so that it acts as a pump for air sacs, and yet, it had the
ancestral features of sharp claws.” (Hou 1996: 1165) This is the first intermediate which has the modern air-sac breathing system of modern birds. It, however, did not have the characteristic of bones that “lie in rows on the dorsal side of the rib cage.” (Holz 1997) Even though these enantiornithine organisms had many bird like characteristics, it did not fully fit the definition of a modern day bird.

It has been found that the intermediate, *Patagopteryx*, has physiological similarities to that of endothermic species and ectothermic species. Though it is often called an enantiornithine bird, these organisms have been grouped into their own category because they had an additional birdlike quality which many enantiornithine birds do not possess. The bird had “a robust body and wings too small for flight.” Feduccia (1996: 289a) This bird also exhibited “lines of arrested growth (LAGS) -bands in the bone which represent yearly increments- were studied, proving that the bird’s metabolism was subject to seasonal growth.” (Fastovsky 1996: 343) It was found, according to Feduccia (1996: 289b), however to be more adaptive to their surrounding temperature, therefore, having more warm-blooded characteristics. A true warm blooded organism would be able to grow independently of temperature fluctuations. The LAGS suggest that temperature influenced development. Therefore, could this mean that the advent of warmbloodedness occurred after the evolution of feathers?

Another group found closer to birds is the Hesperornithiforms. They represent a group of “large, long-necked, flightless diving birds, that used their feet to propel themselves through the water. They have a shortened, fused trunk and a completely fused tarsometatarsus.” (Fastovsky 1996: 317a) Because of the close similarity with that of modern birds, we can assume that these birds were the ancestors of diving birds such as loons and grebes. However, they did have teeth.” (Fastovsky 1996 317) This represents how they were the the next step before evolving into true modern birds.

**Experimental Evidence**

Besides fossilized evidence, there have been extensive research to suggest how the *Archaeopteryx* could have evolved into birds. Since atavistic alterations (aka throwbacks) can be seen as what may be possible ancestral forms, we can study induced mutants to see if the change in development is similar to that of proposed ancestors. In an experiment done by Hampe in 1960, he showed that when a piece of mica is placed between the tibia and fibula before it finishes
development, the resulting bone pattern is very similar to that of the *Archaeopteryx*. The fibula was about the same length as the tibia, instead of being very short as is the case in a normal adult chicken. The tarsus, instead of becoming fused, remained separate (Futuyma 1986: 435). This shows that the *Archaeopteryx* is a possible ancestor to the chicken because the result of this experiment looks like a dinosaurian throwback to the *Archaeopteryx*, which we have postulated to be a possible ancestor of birds.

If birds evolved from dinosaurs, then there should be ways that we can go from bird to dinosaurs which will suggest the progression of steps from birds into dinosaurs. In embryonic chickens there is webbing present between the toes, possibly representing the primitive form. So, there has to be some mechanism that allows the foot of a dinosaur to evolve into the clawed foot of a bird. This experiment is a test to see if there would be a primitive development of the foot, without a certain protein that most likely was part of the transition between dinosaurs and birds. The experiment is described as follows: “At various stages of development, fetuses were injected with a virus that blocked development of a specific set of proteins in one of their limbs. In chicken embryos, the webbing of the toes was not absorbed and the webbed feet were retained. The feet of tetrapods are inherently webbed. This demonstrates that at a certain point in the development of the fetus, the tissue between the digits recedes, leaving the toes free. The exception to this is the webbed feet of ducks.” (Poling 1997)

One of the biggest discrepancies between birds and dinosaurs is the orientation of the pubis bone. In theropods the pubis bone points forwards, whereas in birds, it points backwards. However when embryonic chicken development was studied, it was observed that initially the bone points forward and rotates toward the front during development. The primitive condition (of the embryo) is the same as that found in theropods. This shows that the differing orientation of the pubis bone is not as significant as it appears to be.

Could birds really be traced back to the time of dinosaurs? According to Feduccia, “between 145 and 65 million years ago, virtually the only modern birds alive were shorebirds, for those 80 million years a diverse batch of opposite birds [enantiornithines-sparrow sized, arboreal birds with well-developed flight capabilities] dominated the avian world.” (Zimmer 1995: 42a) Then, he contemplates what happened when an asteroid hit, where the only organisms leftover were shore birds and shrew-like mammals. He pointed out that within 10 million years, “the
shorebirds had to have given rise to the major water-bird and land-bird lineages.” Carl Zimmer cites Alan Cooper and David Penney in their study of the DNA of feathers to provide some support of bird evolution. “They determined how many base changes are separated one species from another within the same order. They found that the difference of any two modern species was 20 to 25 bases. The two scientists pointed out that it must have taken at least 55 million years for 20 to 25 mutations to occur in bird DNA. (Zimmer 1995: 42b) The fast modern bird then would have been around 55 million years ago, which is 10 million years after the extinction of dinosaurs. This would have given intermediates a chance to evolve into modern birds. Some lineages of modern birds may have lived along side these opposite birds and probably have descended from them.

**Alternative theses**

One possible thesis is that birds evolved from mammals. One feature found in common with the two is the “erect posture which occurs in birds and mammals.” (Fastovsky 1995: 333a). This erect posture can be seen as being related to endothermy as “an erect stance is inherently unstable,” and this can only be maintained by a “temperature controlled environment.” (Fastovsky 1995: 333b) Also, if an animal is not erect when it runs, it would tend to compress its sides with each step, only using half of its lung space, which would be the time when it is necessary to breathe in the most air. Another common feature is respiratory turbinates. These are “bony projections at the front end of their nasal cavities.” Its function is to retain as much moisture in the nostrils (Fastovsky 1996: 334). This is a feature which was never found in dinosaurs. If we were to suppose that dinosaurs were warmblooded, then they must have had some system in order to maintain moisture in their lungs which we are unable to determine by simply looking at the fossils. Since many of these probable bird-mammal links can be compared with bird-dinosaur links, and only intermediates from the bird-dinosaur connection have been found, it is most likely that these are convergent features, evolving several times throughout history.

Let’s say that it was not dinosaurs that evolved into birds, but rather the flying reptiles, Pterosaurs. We can start to examine this by tracing the lineage of Pterosaurs. The first evolutionary radiation had the following characteristics: small-medium sized bodies, long tails, and set-in eye sockets. None of those are the same as those found in birds. The second radiation had different characteristics in that they were very large, they had lost their teeth, and also their long
bony tails. Both the loss of teeth and the loss of the tail may suggest that this is a step in the Pterosaur becoming a bird. However, the construction of their large wing span, and rudder like head shows that they relied on help from breezes (i.e. sea breezes) to fly. Also, if we look at the wing structure we can see that the wing extends its entire arm, whereas the wing of a pterosaur is only supported by a single finger. “So when the epicontinental seas retreated at the close of the Cretaceous Period, the pterosaurs were doomed to extinction.” (Feduccia 1980,28) Leaving no descendants after the Cretaceous, there is no possible way that they evolved into birds.

Suppose birds evolved from crocodiles. There are few other shared features that birds and crocodiles possess other than a four-chambered heart. The main similarities between the two is based on the similar braincase and respiratory turbinates. Since birds share many more characteristics with theropod dinosaurs than with crocodiles, it is not likely that crocodiles are the ancestors of birds, but they rather share a common dinosaurian ancestor.

**Conclusion**

Dinosaurs are the most likely candidates of the ancestors of birds. Thus far, an extensive amount of the evidence point to this fact. The fossil record clearly points out each step in the evolution of birds. First of all, there have been many correlations found between dinosaurs and birds. Because birds are a monophyletic group, they must have all came from a single ancestor. Second of all, there are intermediates that exemplify both the dinosaurs and birds. The order of these intermediates, according to Futuyma (1996: 289), is reflected in a “traditional classification system which attempts to reflect both common ancestry and the amount of evolutionary divergence in morphology.” However, there is still a great amount of debate over this topic mostly due to the imperfection of the fossil record. In the future, we may be able to fill in more of the gaps and link with the finding of fossils. Maybe we will be able to construct more experiments with atavistic Alterations, and test to see if birds grow teeth like their ancestors. However, as long as the fossil record remains imperfect, we will never have a direct answer to this question as to how birds evolved.
WORKS CITED


Figure 1. The most prominent belief for the evolution of birds. (Adapted from Zimmer 1997)
   It has been seen that they evolved from a type of theropod dinosaur, known as dromeosarids.

Figure 2. The Unenlagia was found to be an important intermediate between birds and dinosaurs. According to Laura Tangle (1997: 47), it had a shoulder which allowed the animal to move its arms forward, and “permitted an up-and-down flapping motion.

Figure 3. The Oviraptor was found to be guarding its eggs in a (Lemonick, 1996: 62) “a way of having “its legs tucked carefully under the body and its arms curled around the perimeter of the nest, just like a barnyard chicken. This represents the brooding behavior.” Also, it had a wishbone and did not have the characteristic of teeth.

Figure 4. This is the London specimen of Archaeopteryx. (Adapted from Feduccia 1996)
   It represents one of the first specimens found which did display intermediate characters between birds and theropod dinosaurs. It had the ancestral features of teeth, tail and claws. However, it had the birdlike features of feathers and a wishbone.

Figure 5. This describes how a theropod, Deinonychus, has a similar moonshaped-structure of bones in the wrists as that of Archeopteryx.(Adapted from the British Museum of Natural History) This demonstrates how it retained many ancestral features.

Figure 6. This is a model of Hersperornis. (Adapted from Feduccia 1980) It represents an intermediate which is more birdlike than Archaeopteryx. It had, according to Feduccia (1980: 66-67), an “unkeeled sternum”, which meant that it could not fly. It apparently had teeth. At the top figure, it shows that the clavicle is not fused to form the furcula found in birds. Feduccia further notes that it had a similarity with loons and grebes because it had a “long tibiotarsus with a long bony extension to which powerful extensor muscles and attached.”

Figure 7. This is a representation of several intermediates between the first bird, Archaeopteryx, and that of modern birds. (Adapted from Chiappe 54) As you can see, they all have ancestral dinosaurian features and that of modern birds. As the branches go to the right, they have more birdlike characteristics.

Figure 8. This is a comparison of the pterodactyl wing and the bird wing. (Adapted from the British Museum of Natural History) It can be seen that the wings are very distinct. First of
all, the bird wing had a set of feathers covering the whole wrist, whereas, the pterosaur wing was just an extension of a single finger. Due to the large wingspan, it shows, according to Feduccia (1980: 28), that they had to rely on breezes to fly.
Is *Archaeopteryx* most closely related to saurischian dinosaurs?

This is *Deinonychus*, a member of a group of saurischian dinosaurs called theropods. Theropods walked on two legs and most ate meat.

*Deinonychus* and *Archaeopteryx* have similar moon-shaped bones in their wrists (shown in red on the diagrams). Many scientists believe that this feature is a unique homologue, not shared by other archosaurs. So they claim that dinosaurs such as *Deinonychus* are the birds' closest relatives.
Figure 8

wing of *Archaeopteryx*

wing of *Rhamphorhynchus*, a pterosaur

* A pterosaur's wing was used for gliding, whereas we now believe that *Archaeopteryx* was capable of flapping flight.