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# Competitive Exams: Evolution Time Scale: Archaeopteryx

## The Features of the Archaeopteryx

The features of the Archaeopteryx ( "primitive bird" ) have been described so often, and such excellent pictorial restorations of its appearance may now be seen, that we may deal with it briefly. We have in it a most instructive combination of the characters of the bird and the reptile. The feathers alone, the imprint of which is excellently preserved in the fine limestone, would indicate its bird nature, but other anatomical distinctions are clearly seen in it. "There is," says Dr. Woodward, "a typical bird's 'merrythought' between the wings, and the hind leg is exactly that of a perching bird." In other words, it has the shoulder-girdle and four-toed foot, as well as the feathers, of a bird. On the other hand, it has a long tail (instead of a terminal tuft of feathers as in the bird) consisting of twenty-one vertebrae, with the feathers springing in pairs from either side; it has biconcave vertebrae, like the fishes, amphibia, and reptiles; it has teeth in its jaws; and it has three complete fingers, free and clawed, on its front limbs.

As in the living Peripatus, therefore, we have here a very valuable connecting link between two very different types of organisms. It is clear that one of the smaller reptiles--the Archaeopteryx is between a pigeon and a crow in size--of the Triassic period was the ancestor of the birds. Its most conspicuous distinction was that it developed a coat of feathers. A more important difference between the bird and the reptile is that the heart of the bird is completely divided into four chambers, but, as we saw, this probably occurred also in the other flying reptiles. It may be said to be almost a condition of the greater energy of a flying animal. When the heart has four complete chambers, the carbonised blood from the tissues of the body can be conveyed direct to the lungs for purification, and the aerated blood taken direct to the tissues, without any mingling of the two. In the mud-fish and amphibian, we saw, the heart has two chambers (auricles) above, but one (ventricle) below, in which the pure and impure blood mingle. In the reptiles a partition begins to form in the lower chamber. In the turtle it is so nearly complete that the venous and the arterial blood are fairly separated; in the crocodile it is quite complete, though the arteries are imperfectly arranged. Thus the four-chambered heart of the bird and mammal is not a sudden and inexplicable development. Its advantage is enormous in a cold climate. The purer supply of blood increases the combustion in the tissues, and the animal maintains its temperature and vitality when the surrounding air falls in temperature. It ceases to be "cold-blooded."

But the bird secures a further advantage, and here it outstrips the flying reptile. The naked skin of the Pterosaur would allow the heat to escape so freely when the atmosphere cooled that a great strain would be laid on its vitality. A man lessens the demand on his vitality in cold regions by wearing clothing. The bird somehow obtained clothing, in the shape of a coat of feathers, and

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had more vitality to spare for life-purposes in a falling temperature. The reptile is strictly limited to one region, the bird can pass from region to region as food becomes scarce.

## The Origin of the Feathers

The question of the origin of the feathers can be discussed only from the speculative point of view, as they are fully developed in the Archaeopteryx, and there is no approach toward them in any other living or fossil organism. But a long discussion of the problem has convinced scientific men that the feathers are evolved from the scales of the reptile ancestor. The analogy between the shedding of the coat in a snake and the moulting of a bird is not uninstructive. In both cases the outer skin or epidermis is shedding an old growth, to be replaced by a new one. The covering or horny part of the scale and the feather are alike growths from the epidermis, and the initial stages of the growth have certain analogies. But beyond this general conviction that the feather is a development of the scale, we cannot proceed with any confidence. Nor need we linger in attempting to trace the gradual modification of the skeleton, owing to the material change in habits. The horny beak and the reduction of the toes are features we have already encountered in the reptile, and the modification of the pelvis, breast-bone, and clavicle are a natural outcome of flight.

In the Chalk period we find a large number of bird remains, of about thirty different species, and in some respects they resume the story of the evolution of the bird. They are widely removed from our modern types of birds, and still have teeth in the jaws. They are of two leading types, of which the Ichthyornis and Hesperornis are the standard specimens. The Ichthyornis was a small, tern-like bird with the power of flight strongly developed, as we may gather from the frame of its wings and the keel-shaped structure of its breast-bone. Its legs and feet were small and slender, and its long, slender jaws had about twenty teeth on each side at the bottom. No modern bird has teeth; though the fact that in some modern species we find the teeth appearing in a rudimentary form is another illustration of the law that animals tend to reproduce ancestral features in their development. A more reptilian character in the Ichthyornis group is the fact that, unlike any modern bird, but like their reptile ancestors, they had biconcave vertebrae. The brain was relatively poor. We are still dealing with a type intermediate in some respects between the reptile and the modern bird. The gannets, cormorants, and pelicans are believed to descend from some branch of this group.

The other group of Cretaceous birds, of the Hesperornis type, show an actual degeneration of the power of flight through adaptation to an environment in which it was not needed, as happened, later, in the kiwi of New Zealand, and is happening in the case of the barn-yard fowl. These birds had become divers. Their wings had shrunk into an abortive bone, while their powerful legs had been peculiarly fitted for diving. They stood out at right angles to the body, and seem to have developed paddles. The whole frame suggests that the bird could neither walk nor fly, but was an excellent diver and swimmer. Not infrequently as large as an ostrich (five to six feet high), with teeth set in grooves in its jaws, and the jaws themselves joined as in the snake, with a great capacity of bolting its prey, the Hesperornis would become an important

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element in the life of the fishes. The wing-fingers have gone, and the tail is much shortened, but the grooved teeth and loosely jointed jaws still point back to a reptilian ancestry.

These are the only remains of bird-life that we find in the Mesozoic rocks. Admirably as they illustrate the evolution of the bird from the reptile, they seem to represent a relatively poor development and spread of one of the most advanced organisms of the time. It must be understood that, as we shall see, the latter part of the Chalk period does not belong to the depression, the age of genial climate, which I call the Middle Ages of the earth, but to the revolutionary period which closes it. We may say that the bird, for all its advances in organisation, remains obscure and unprosperous as long as the Age of Reptiles lasts. It awaits the next massive uplift of the land and lowering of temperature.

In an earlier chapter I hinted that the bird and the mammal may have been the supreme outcomes of the series of disturbances which closed the Primary Epoch and devastated its primitive population. As far as the bird is concerned, this may be doubted on the ground that it first appears in the upper or later Jurassic, and is even then still largely reptilian in character. We must remember, however, that the elevation of the land and the cold climate lasted until the second part of the Triassic, and it is generally agreed that the bird may have been evolved in the Triassic. Its slow progress after that date is not difficult to understand. The advantage of a four-chambered heart and warm coat would be greatly reduced when the climate became warmer. The stimulus to advance would relax. The change from a coat of scales to a coat of feathers obviously means adaptation to a low temperature, and there is nothing to prevent us from locating it in the Triassic, and indeed no later known period of cold in which to place it.

It is much clearer that the mammals were a product of the Permian revolution. They not only abound throughout the Jurassic, in which they are distributed in more than thirty genera, but they may be traced into the Triassic itself. Both in North America and Europe we find the teeth and fragments of the jaws of small animals which are generally recognised as mammals. We cannot, of course, from a few bones deduce that there already, in the Triassic, existed an animal with a fully developed coat of fur and an apparatus, however crude, in the breast for suckling the young. But these bones so closely resemble the bones of the lowest mammals of to-day that this seems highly probable. In the latter part of the long period of cold it seems that some reptile exchanged its scales for tufts of hair, developed a four-chambered heart, and began the practice of nourishing the young from its own blood which would give the mammals so great an ascendancy in a colder world.

## Lack of Evidence

We cannot complain of any lack of evidence connecting the mammal with a reptile ancestor. The earliest remains we find are of such a nature that the highest authorities are still at variance as to whether they should be classed as reptilian or mammalian. A skull and a fore limb from the Triassic of South Africa (Tritylodon and Theriodesmus) are in this predicament. It will be remembered that we divided the primitive reptiles of the Permian period into two great groups, the Diapsids and Synapsids (or Theromorphs).

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The former group have spread into the great reptiles of the Jurassic; the latter have remained in comparative obscurity. One branch of these Theromorph reptiles approach the mammals so closely in the formation of the teeth that they have received the name “of the Theriodonts” or “beast-toothed” reptiles. Their teeth are, like those of the mammals, divided into incisors, canines (sometimes several inches long), and molars; and the molars have in some cases developed cusps or tubercles. As the earlier remains of mammals which we find are generally teeth and jaws, the resemblance of the two groups leads to some confusion in classifying them, but from our point of view it is not unwelcome. It narrows the supposed gulf between the reptile and the mammal, and suggests very forcibly the particular branch of the reptiles to which we may look for the ancestry of the mammals. We cannot say that these Theriodont reptiles were the ancestors of the mammals. But we may conclude with some confidence that they bring us near to the point of origin, and probably had at least a common ancestor with the mammals.

The distribution of the Theriodonts suggests a further idea of interest in regard to the origin of the mammals. It would be improper to press this view in the present state of our knowledge, yet it offers a plausible theory of the origin of the mammals. The Theriodonts seem to have been generally confined to the southern continent, Gondwana Land (Brazil to Australia), of which an area survives in South Africa. It is there also that we find the early disputed remains of mammals. Now we saw that, during the Permian, Gondwana Land was heavily coated with ice, and it seems natural to suppose that the severe cold which the glacial fields would give to the whole southern continent was the great agency in the evolution of the highest type of the animal world. From this southern land the new-born mammals spread northward and eastward with great rapidity. Fitted as they were to withstand the rigorous conditions which held the reptiles and amphibia in check, they seemed destined to attain at once the domination of the earth. Then, as we saw, the land was revelled once more until its surface broke into a fresh semi-tropical luxuriance, and the Deinosaurs advanced to their triumph. The mammals shrank into a meagre and insignificant population, a scattered tribe of small insect-eating animals, awaiting a fresh refrigeration of the globe.