results. Professor Harkness has great hopes of photography as an auxiliary in this direction.

THE ANTHROPOLOGICAL SOCIETY.—Four papers were read in October, all of them mythological and all of permanent value, to wit: the Buffalo Woman: an Omaha Myth, by the Rev. Owen Dorsey; Myths of the Wintuns, by Major J. W. Powell; the Stone God of the Putepemni, by the Rev. S. D. Hurman; and the Dangers of Symbolic Interpretations, by Col. Gerrick Mallery. It is impossible to give an abstract of a myth. We can only say that Major Powell years ago conceived the idea of studying myths by the Baconian method. He told the writer of this sketch, "there are books and books on mythology, but very few myths. I will collect a volume of well authenticated myths, from which mythologic philosophy can be deduced." The Major has himself gathered a great number, and Messrs. Dorsey and Hurman were for many years missionaries among the Dakotas, speaking their language with the greatest freedom. Our readers will be pained to hear that Major Powell has been confined for several weeks by an acute attack of iritis. Colonel Mallery's paper was a thoughtful treatment of the subject of symbolism, neatly considered in its threefold aspect of signs, emblems, and symbols. The North American Indians north of Mexico had not arrived at that psychologic stage wherein true symbolism manifests itself.

THE BIOLOGICAL SOCIETY OF WASHINGTON.—The opening meeting of the Biological occurred on the evening when the city was all excitement over the reception of our French and German guests. The session of Friday, October 28th, however, was one of considerable interest. Professor Lester F. Ward exhibited an example from the petrified forests of Wyoming, mimicking the paw of an animal, which elicited a discussion as to the formation of agates and other minerals of that character.

Mr. Henry Elliot's communication on the biology of the Sea-Otter was very instructive. Little is known of the habit of this animal, the stuffed specimens in the museums conveying a very poor notion of its form. It is supposed to breed on the great beds of kelp which float in the northern seas, having one pup at a birth. Its fur is a hundred times more valuable than all other fur products combined. The hunting is especially dangerous and requires great skill.

Professor Thomas Taylor exhibited and described a freezing microtome, in which the cooling effect of a current of water from salt and ice is used to produce the hardening. The extreme cheapness, simplicity, and practicability of this apparatus will enable the microscopist to dispense with the more costly and difficult methods hitherto used for obtaining thin sections of tissues and for examining the brain and other soft parts of the body in a rigid condition.

THE EVOLUTION OF FLYING ANIMALS.

By CHARLES MORRIS.

There are some questions in Biological science which it will be difficult, if not impossible, to settle by an appeal to facts, and in the investigation of which we are obliged to employ a degree of speculation. Thus we have abundant reason to believe that birds are direct derivatives from reptiles. We know, in fact, that these animals resemble each other in such essential particulars as to justify the grouping of them together in a single vertebrate section, the Sauropsidæ of Huxley. We can even trace, by aid of the palæontological record, some of the steps by which birds arose from their reptilian progenitors. And yet no definite hypothesis has been advanced as to how the scales of the reptile became the feathers of the bird, how the quadrupedal habit of the one became the bipedal habit of the other, or how the walking changed to the flying method of locomotion.

These questions we cannot now, and perhaps may never be able to, answer with the argument of facts. But if some probable mode by which such variations may have arisen can be suggested, the speculation will hardly be an empty one. All the great theories of science have simply the force of highly probable speculations, based on known facts; and lesser theories, if given the same basis, may prove equally desirable.

One of the most striking features in animal life is its tendency to spread outwards, functionally, in every possible direction, so as to occupy each field of nature in every advantageous manner. One-half of the animal world seeks to feed on the other half, while this second half seeks to escape being fed upon. This is one of the main elements of natural selection. Every change in organization that proves an advantage to the carnivorous animal in assailing his prey, is apt to be retained. Every change that aids his prey in escaping is likewise retained. Through this cause there have been continual variations, since every favorable change in the one class would prove injurious to the other class, unless met by an equal counter change.

In this long continued process of adaptation to circumstances, every advantage offered by water and land to their animal inhabitants, in overcoming their prey, or in escaping from their enemies, has been long since adopted, and an immense variety of animal forms has arisen in consequence. But the air also presents favorable conditions both for escape and pursuit, and the adaptation of animals to aerial flight is so obviously advantageous, that it must have arisen as soon as the developing organization of animal life, and the occurrence of the necessary terrestrial conditions, rendered it possible.

In considering the problem of how flight originated, it will be desirable to take up successively the three questions above given. First, how did scales become feathers? The three higher classes of vertebrate animals have each its peculiar dermal covering. The Reptile has its bony plates, or its scales, the Mammal its hairs, and the Bird its feathers. Scales, hairs, and feathers are alike in origin, and are but specialized forms of a similar epithelial outgrowth. Yet these three classes of animals seldom invade each other's province. No reptile has a hairy or feathery coating. If mammals and birds were evolved from reptilian progenitors, the change of scales into hairs and feathers forms one of the processes of this evolution, and should be explicable under the natural selection hypothesis.

Certainly reptiles never became feathered through the Lamarckian process. No effort to fly, however vigorous, could have converted the scale of the reptile into the feather of the bird. It would be useless for flight until it had become almost a perfect feather, and therefore there could be no moulding influence upon its intermediate stages. The rudimentary feather must have arisen under the pressure of some other influence, and its adaptation to flight must have been a secondary resultant.

If we ask, what is the rudimentary feather, we seem to find it in the hair. In the larger land birds, as the Ostrich, the feathers on some parts of the body are indistinguishable from hairs; and in the tails of flying-squirrels the hairs spread out in a manner that seems preliminary to a development into the feathery condition. We may begin by asking, then, through what process of natural selection did the scale develop into the hair?

In seeking to solve this problem we first ask, what advantage has the hair over the scale as a dermal covering? The only positive answer we can make to this is, that it has greater warmth. It enables the haired animals to endure degrees of cold which would be fatal to the scaled animals. This difference in covering has a marked effect on the lives of the two classes of animals. Through the wide possibilities of increase in length and thickness of their hairy coat, mammals can endure the greatest extremes of winter temperature, while reptiles are strictly summer animals, those inhabiting the colder zones being forced to hibernate during the winter. Existing reptiles, then, have no need of a warmer covering than they possess. Their localities and life habits render this sufficient to protect them from all the changes of temperature to which they are exposed during their period of activity. But if the possession of a hairy covering would have enabled the reptiles of the past to remain active throughout the whole year in cold climates, why was it not developed? The answer is that it would have been of no special advantage to them. They are otherwise unfitted for activity during the season of low temperature, and to adapt them to this condition, not only their outer covering needed to be modified, but their internal organization as well. This change in organization has taken place in many cases, and with it the development of a warmer covering than the reptilian coat. But the reptile, thus modified, has lost its reptilian character. It has, in the one case, with other less important changes, become a bird; in the other case, with other more important changes, it has become a mammal.

The change in internal organization referred to is that in the circulating system. The imperfect heart, the sack-like lung, and the half-ærated blood of the reptile have developed into the perfect heart, the unlike but widely-extended lungs, and the fully ærated blood of the mammal and the bird. The varying temperature of the reptile is exchanged for the unvarying temperature of his successors. The so-called cold-blooded reptile, with its insufficient oxygenating organs, is at a disadvantage as compared with the bird and the mammal, with their fully oxygenated blood.

To bodily activity is necessary an internal temperature sufficiently high to render the organic chemistry of the body active. In the temperature of the tropics, and the summer temperature of the extra tropical zones, all animals possess this temperature, and none are at a disadvantage in this particular. But the reptile depends directly on the solar heat for its temperature, the bird and the mammal do not. Thus when the temperature falls the internal temperature of the reptile similarly decreases, its organic chemical change declines in activity, it becomes sluggish in movement, unable to obtain food, and would perish but for the hibernating habit which is customary with it. But the bird and the mammal preserve the temperature essential to organic chemical activity. They continue, therefore, awake and energetic, and in a condition to obtain the necessary food-supply.

The reptile is essentially a tropical animal. Its organization unfits it for the extremes of extra tropical temperature, and it is active in the temperate and frigid zones only during the tropic heat of their summers, but conceals itself and continues torpid during the cold of their winters.

Birds and mammals are essentially adapted to a life in the colder zones. They must have originated in regions in which wintry cold, for some part of the year, replaced the summer heat. The reptilian circulation sufficed for the needs of animals bathed in a fixed degree of external heat, high enough to promote their bodily activity. But animals exposed to severe cold during any portion of the year must either hibernate during that period, or must gain an improved circulation. The heat which fails them without must be produced within, or their activity must cease.

This is what we must understand from the systems of circulation of the bird and the mammal. Their reptilian progenitors slowly gained more complex lungs with an increased ærating surface; the blood became more fully oxygenated; the arterial and venous blood became more completely separated in the chambers of the heart; and as a natural result the internal temperature increased. Such slight changes could not have been preserved and augmented unless of advantage. They would have been of no special advantage to the tropical animal. To the animal of the temperate zones they were decidedly advantageous, in enabling it to remain active during a greater portion of the year, and finally during the whole year, the internal stores of heat replacing the lost external stores when winter replaced summer.

But these internal stores must not only be produced, but must be retained. A heat-retaining covering is necessary to hinder the chilling effect of the wintry air. The reptilian scale is obviously not sufficient for this purpose. As the internal heat of the animal increased, and it was able to prolong its period of active life more and more into the cold season, some modification of the scale became necessary, so as to make it more efficient in retaining this internal heat. The scales may, from their points of origin, have grown out longitudinally, covering each other in successive layers, and thus forming a warmer and closer covering. Such a process of elongation, if accompanied by a narrowing of the individual points of origin, would, in time, convert the the scale into a hair. It is well known that they are capable of becoming so converted, by such an elongating outgrowth.

Thus the haired and feathered animals could not have arisen until the possibly general summer of early times was replaced by a double season of summer and winter in the extra tropical regions. But though thus of temperate origin, there was nothing to hinder their spreading both into the frigid and the tropic zones. Their improved circulation gave them an activity superior to that of the preceding reptilian rulers of the tropics, and they thus had an advantage in the life battle, which soon showed its effects. The giant reptiles disappeared and giant mammals took their place. Gradually the reptiles retreated before the march of the mammals. They sank to the ground, hid in holes, learned to creep, to squirm, to swim, while their mammalian successors proudly stalked over their conquered realm, the lords of the earth.

If this, through the advantage gained by adaptation to wintry cold, animals were evolved possessed of a perfect circulation, a fixed internal temperature, and a poorly conducting external covering of hair; and if these animals, through their improved powers, banished their reptilian predecessors, or forced them to retreat to the waters, the holes, and the dark recesses of the earth; it remains to consider the subsequent variations of these hair covered animals; or, at least, of the flying sections of these creatures.

The next question to be considered is that of the change from a quadrupedal to a bipedal habit of motion. There is only one true biped among the whole great class of mammals, namely, man. He is approached in this bipedal habit by the higher apes, and it is not difficult to understand how the specialization of limbs took place in the latter. It undoubtedly arose from the climbing habits of monkeys. The fore limbs became used as grasping organs, the hind limbs as supporting organs. As climbing monkeys increased in size, they must in many cases have moved by grasping upper branches with their hands, and supporting their feet on lower branches. This was an imperfect bipedal movement. Eventually some of them became too heavy to render a continual arboreal residence desirable. These came to spend the most of their lives upon the earth, as we find in the larger apes of the present day. But these apes are neither quadrupeds nor bipeds. The specialization of their limbs during a long arboreal residence has unfitted them for either mode of motion upon the ground, and they move along in an awkward and inefficient compromise between the two modes of motion. Evidently the method of progression of these animals is not a desirable one for a land residence. Natural selection must tend to make them full quadrupeds or full bipeds. Those of them which have recently changed their arboreal for a ground habitat, have not had time to change. Those which earlier descended to the earth have evolved improved methods of progression. The most of them have returned to the quadrupedal condition, if we may conceive the four-footed baboons to have arisen in this manner. As to whether any of them have gained the perfected bipedal condition, it is perhaps best to make no assertion. Those who hold that man had an ape-like progenitor, must accept this view.

There are other mammals with partially bipedal habits. These compromise the jumping animals, the kangaroos, jerboas, etc. But in these cases there has been no specialization of the fore-limbs. They have simply become partly aborted. The bear also, through its plantigrade feet, and perhaps its climbing habit, has gained imperfect bipedal powers, and a grasping habit with its fore limbs. But there has been no specialization of these limbs. They continue true walking organs.

In the reptilian world other instances of bipedal habits present themselves, developed in still another manner.

The animals thus organized are all creatures of a vanished age—the huge Deinosaurian reptiles presented to us in the geological record. These creatures may have gained their specialization of form through the same cause, though not in the same manner, as the giraffe gained its special formation. Many of them lived by browsing on the foliage of trees. And these, instead of developing an elongated neck, like the giraffe, probably obtained their food by a partially climbing process. Their fore limbs clasped the tree trunk, while their weight rested on the hind limbs and the tail. In this manner they were able to reach the desired food.

A long continuance of such habits would produce, through selection, a specialization of the fore limbs. To become efficient organs for grasping tree trunks, they must have become inefficient walking organs. Through this specialization the fore limbs seem to have become small and comparatively weak, the hind limbs large and powerful. To look at the remains of these creatures now, as preserved for us in the rock strata, it seems as if a quadrupedal motion must have been very awkward and inefficient; while their habit of erecting themselves on their hind legs, may have rendered a bipedal motion easy and natural. Professor E. D. Cope says of them: "some have chiefly squatted, some leaped on their hind legs like the kangaroo, some stalked on erect legs like the great birds, with their small arms hanging uselessly by their sides." Yet when we consider the great size of these reptiles, which comprise the huge Iguanodon and Megalosaurus, the Hadrosaurus of our New Jersey marl, and other such gigantic creatures, we may well imagine that they presented an appearance widely different from that of any existing creatures. To see animals thirty feet in height and huge in proportion, to whom our elephant would be a mere pigmy, stalking about erect on their hind legs, would certainly be an astonishing spectacle. Yet such a view was very probably presented by that bizarre world of the past which time has swept away.

These Deinosaurian reptiles, with their peculiarities of structure, their hollow bones, and their three-toed feet, presented certain strong affinities to the great land birds of modern times. So close, indeed, that some have conjectured that these large wingless birds, such as the Ostrich, are direct descendants of the Deinosaurs. In this claim there are no powers of flight to be explained, yet the possession of feathers by the ostrich seems a fatal obstacle to the hypothesis. Feathers are a highly specialized form of dermal covering. They are specially adapted to purposes of flight, and we can imagine for them no other use which the less specialized hairs or scales would not have subserved. We are therefore disposed to conclude that any animals possessed of feathers must have gained them through powers of flight in themselves or their ancestors; and that the resemblances in organization above mentioned arose from similarity in modes of progression, and not from hereditary connection.

How, then, was the further step in the process taken? The primitive hairy covering being gained, how did hairs develop into feathers, how were the imperfect bipeds among land animals succeeded by the perfect bipeds among flying animals, and how did motion upon the earth develop into motion through the air? It certainly did not arise as a result of leaping habits. We cannot imagine the spring of a kangaroo as so advantageously aided by an accidental conformation of the fore limbs, as to produce a natural selection of this conformation. If these leaping animals habitually sought to assist their flight by a motion of the fore limbs, then any membraneous expansion or special thickness of hairy covering would be advantageous. But none of those now existing have such a habit, and without it their leap could never become a flight.

(*To be continued.*)

THE NEW COMPRESSED AIR LOCOMOTIVE.

On the 13th ultimo a trial of a new engine built by the Baldwin Works, Philadelphia, took place on the Second Avenue Railroad, the result of the trial being on the whole satisfactory. Compressed air as a motive power for railway engines has been repeatedly tried already in this country and in Europe. At Paris and Nantes the Mekarski Air Engine has at different times been used with more or less success, at Glasgow. Mr. Scott Moncrieff has labored perseveringly to demonstrate the superiority of compressed air over steam for locomotive purposes, while in June last year Col. Beaumont produced (in London) an engine which was thought at the time to have eclipsed its predecessors in point of efficiency and small working cost. The "success," however, of these engines has been so very undecided, and the advantages they presented in point of cleanliness, and absence of smoke and noise, have been so counterbalanced by the cost of compressing and storing the air, that as yet we have heard of no line of railroad or tramway being *successfully* worked by compressed air.

Comparing the data obtainable from these engines with the result of the late trial, we find a decided superiority in the efficiency of the American engine which possesses several new and important features, and is the result of long experience and study of the subject by the inventor and patentee, Mr. Thos. Hardie, the Pneumatic Company's Chief Engineer.

A short description of the engine and its trial may not be uninteresting to our readers. In length and weight it is as nearly as possible the same as an average Elevated Railroad engine, the part usually reserved for the boiler being in this case occupied by the receivers for containing the air, four in number and of unequal lengths, having an aggregate capacity of 460 cubic feet, in which air is stored at a pressure of 600 lbs. per square inch. Inside the cab is a small boiler (the consumption of coal in which is nominal) through which air from the receivers is passed before being allowed to enter the cylinders. An automatic throttle valve on the supply pipe of this boiler regulates the pressure at which the cold air enters the boiling water. The air being thus heated expands and the pressure is of course considerably augmented, and in this hot, moist condition it passes into the cylinders, having a far larger percentage of efficiency than if it were allowed to do so in a cold, dry condition. There is thus by this means a great saving in the quantity of air consumed. The system of drawing air from the reservoir at a low pressure and expanding it by heat until it attains a working pressure of from 100 to 130 lbs. per square inch is, we believe, entirely novel, and in this respect the engine differs altogether from Col. Beaumont's machine, in which air was admitted to the cylinders at its initial reservoir pressure—1000 lbs., and then quickly cut off.

In a former engine built by the Pneumatic Company