Saint-Gervais and the heights of Belleville. Their quality leaves much to desire.

"Essentially selenitic, their hydrometric degree reaches enormous proportions: 100 degrees to 150 degrees according as the waters of Saint Gervais and of Belleville are more or less mingled." They contain very little organic matters, some rare algæ and many calcareous crystals.

The well of Grenelle, become celebrated, was commenced in 1833 and only finished in 1841. It was on the occasion of its boring that the relations of the elevation of temperature to the depth of the soil observed by Arago and Walferdin, were stated; that is to say, with every 32 metres the temperature rises one degree.

The water of the well of Grenelle (fig. 7) lacks oxygen which it can gain in the basins of the Pantheon where it is conducted. This water is limpid, indicates at its outlet about 28 degrees, and is very nearly pure from all organism, since it only contains some traces of mycélium of mushrooms (No. 2) and, here and there, several Diatoms (No. 1) probably drawn from the tubes through which it flows. The traces of sulphuretted hydrogen which it contains, impairs a little the quality of this water, but not enough to make it unfit for consumption.

The water of the well of Passy, perforated from 1854 to 1861, can be compared with that of Grenelle (fig. 8). The results which the piercing of this well caused are known; the sale of the water of Grenelle was made considerably less. The carbonate of lime, as well as the bicarbonate of potash, are abundant in both. All things equal, moreover, M. Neuville gives his preference for the waters of Passy rather than for those of Grenelle. Several algæ are found in them (*Calothrix* [No. 8], *Rhizoclonium* [No. 5], *Cosmarium* [No. 1], Glœocystis [No. 9]); several encysted infusoria (No. 2), and a few unimportant organic remains.

Lastly, the waters of ordinary wells are potable only when they are not found in a great city. The varied infiltrations, the connection with the soil, and the industries which can contaminate them, are considerations which must be taken into account in deciding the quality of the waters of wells, and which can render them unfit for consumption. They contain at Paris much of the nitrate and sulphate of lime, and they are also very much charged with organic matters in a state of decomposition; but of algæ there is no trace and there are, here and there, several microscopic crustaceans. It is above all in the neighborhood of cemeteries that the waters of wells should not be used except for gross purposes. This advice is upheld by the studies of M. Belgrand, who has observed that, in the environs of Père-Lachaise and of the cemetery of Montparnasse, the waters of wells were stocked, above all during the heat of summer.

Basing his results on microscopical analyses, M. Neuville arranges the waters of Paris in the following order to indicate their degree of purity: 1, waters of the Vanne; 2, of the Marne at Saint-Maur; 3, of the Marne at Charenton; 4, of the Seine at Port-à-l'-Anglais; 5, of the canal of Ourcq; 6, of Arcueil; 7, of the sources of the Nord; 8, of the wells of Passy; 9, of Grenelle; 10, of the Dhuis; 11, of the Seine at the bridge of Austerlitz; 12, of a well on the left bank; 13, of the Seine at Saint-Ouen; 14, at Auteuil; 15, at Chaillot.

Tidal Power at Bristol.—At a recent meeting of the Town Council of Bristol a motion was brought forward, but not adopted, that "instructions be given to the sanitary authority to cause inquiries to be made into the tidal power of the Avon with a view to its being utilized for working electric lights for the city, the storage of motive power and other purposes, and that scientific aid be employed for the purpose."

THE EVOLUTION OF FLYING ANIMALS.

By Charles Morris.

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Yet there is one instance of a leaping animal in which a partial flight has been gained in this manner. We allude to the flying-fish. Whatever first induced this creature to spring from the water through the impulse of its swimming motion—whether the pursuit of enemies, or some other cause—at any rate its fore limbs were already developed into wing-like organs, through their use as fins. The flying-fish does not really fly. But an increased spread of its supporting fins, which act as parachutes, would enable it to make longer leaps, and natural selection has undoubtedly produced this extension of the fins.

Land animals present us with several instances of this parachute motion. And significantly it never arises in earth-leaping, but always in tree-leaping animals. Among mammals we find three instances of such a habit, in widely separated families, embracing the Flying Squirrel, the Flying Phalanger, and the Flying Lemur. Among reptiles there is one instance, the Flying Dragon. The three mammalian genera mentioned include a number of species, and an imperfect flight is gained in the same manner in every case. During their so-called flight the limbs are extended almost at right angles to the body, and the skin of the sides has been developed until it is expanded into a broad membrane between these limbs, which, in the case of the Flying Lemur, extends from the nape of the neck to the tail. In their bold leaps from the branches of trees these creatures are partly supported by their membraneous wings, so that they descend slowly and easily. Some of them can even slightly vary the direction of their motion, so as to pursue insects.

The flying reptile, the little Draco Volans, gains its support in a somewhat different manner. In this case the extended membrane is supported, not upon the limbs but upon the false ribs, which grow out horizontally from their vertebral connection to a considerable distance, giving the animal a wing-like expansion of its sides.

We may readily conjecture the method in which such an organization was gained. The smaller tree dwelling animals are exposed to attacks from foes, the same as all other animals. Or, if carnivorous, they need to pursue their prey. In both these cases the power to make long leaps from branch to branch, or from tree to tree, is so obvious an advantage, that it is not surprising that many animals have become very bold and skillful in this particular. Many of these animals have also the habit of crouching on the branches of trees for concealment, their legs being extended side-wise, and their bodies flattened. This position of the legs in rest would most probably be retained during the leaping motion in which they are not employed. If, then, in any case, the width of the body should be increased, as by a chance extra expansion of the skin of the sides, supported by the outstretched limbs, the animal would be borne up by the air, and could make a longer leap. Such a conformation would aid it in flight or pursuit, and natural selection must operate to retain any such special advantage of form. It certainly seems very probable that the supporting membrane of these creatures was thus developed, and that the Flying Dragon gained its rib expansion through a similar process.

These cases may seem of little importance in an investigation of the origin of the flying power in birds; yet they are, in reality, of considerable importance. They point significantly to the most probable method of flight development, namely, as the result of an original leaping habit, from branch to branch or from tree to tree. Although the above cases are instances of parachute motion only, not of true flight, yet we have strong reason to believe that the earliest flying animals gained their power of flight as a direct extension of the above method.

In the incessant battle for existence among animals the possession of powers of flight are, in certain directions, so specially advantageous, that any accident of conformation, aiding animals in any degree to support themselves in the air, seems very likely to be preserved and to be added to. At present, however, when the field of air is so fully occupied, and there are so many vigorous carnivorous birds constantly seeking for poorly defended food animals, the tendency to develop powers of flight is checked. The aerial motion of the leaping animals mentioned is not such as to greatly expose them to danger from this source. But were their powers of flight increased, so that they could support themselves longer in the air, and move out from the immediate shelter of trees, they would be exposed to attacks from carnivorous birds, and such an imperfect flight must prove a special disadvantage. Their weak flight would expose them to a danger from which they could escape neither by rapidity of motion, nor by a return to the shelter of the forest. Thus the existence of these strong carnivorous birds operates as a decided check on the development of any other form of flight, and it is very unlikely that the leaping creatures mentioned will ever develop a more efficient flight.

There is another illustration of the same principle. The true flying mammals, the bats, perhaps developed their powers of flight at the same geological age as birds did. Thus there was no special hindrance to their evolution. It might seem curious to some, however, that they have failed to gain the same extensive habitat as birds; that they are exclusively crepuscular or nocturnal in their habits, while the birds are almost exclusively diurnal. And yet this difference must have arisen in consequence of a long-continued conflict between bats and birds, in which birds conquered. If we consider that the flying organs of birds are more efficient than those of bats, the whole question is answered. The birds drove the bats back into a field which they did not care to occupy. The fight was for the possession of the air during the day. The birds conquered. The bats were forced to content themselves with nocturnal flight and the imperfect food-supplies which the night yields, while the birds proudly held the dominion of day. It was a case somewhat similar to that which we have already considered, of the supremacy of mammals over reptiles; and the disappearance of the flying Pterosaurs of the far past may possibly have been due, both to the superiority of flying powers and to the more efficient vascular system of birds over flying reptiles.

But there was a period in which the haired animal had not yet succeeded the scaled animal, in which hairs had not been specialized into feathers, and in which the broad fields of air were free to the first occupant, and contained no active carnivoræ ready to check the development of flight in its incipient stages. Were such the case now, our Flying Squirrels, etc., might gain more efficient powers in this respect, and evolve true flight. We may safely come to this conclusion from the fact that certain lizards gained powers of flight in the early days of bird evolution, and apparently by a direct continuation of the process which we perceive in the Flying Squirrels. The expanded skin between the legs was merely a thin, naked membrane in these lizards. It apparently spread wider and wider, until it extended to the extremities of the toes. But this condition would only produce a more efficient parachute motion. For flight to arise a movement of the fore limbs must be employed, and this may have originated in the effort to keep the body horizontal and prevent its anterior extremity from sinking. Such a movement, with the possession of such a membrane, would yield an imperfect flight. But for the flight to become perfect, in such an animal, the membrane must become still more extended, and the movement of the fore limbs more efficient. This extension was gained by the gradual outgrowth of the fourth finger, to whose tip the membrane had already extended. By the preservation of favorable variations in this direction, it is very likely that the immensely extended flying finger of the Pterodactyle, the bird-like conformation of its skeleton, and its probably more efficient lung action, were gradually gained; and that it thus developed from an original tree-leaping into a flying reptile.

The advantages of an aerial residence, at that early period when the atmosphere had not yet been preempted by vertebrate inhabitants, were so many and great, that the selective principle must have proved of particular efficiency in this direction. Even a long leap from a solid support infested by many enemies, through an aerial field devoid of enemies, was highly advantageous, and the development of flying powers may have been preceded by the appearance of many animals possessed of a parachute motion. Such animals would leave no geological record, as their motion did not necessarily modify the osseous framework of the body. There are comparatively few of them now, since the advantage to be gained by such powers is greatly reduced. But it is very obvious that any extension of this power, assimilating it to true flight, must have proved far more advantageous. An animal capable of supporting itself in the air, at this early period, was exceptionally free from danger, while its chances to obtain food were greatly increased. The better flyers were, of course, the more secure, and the original partial flight must have rapidly developed into the most perfect flight of which such a membranous wing extension was capable. Not until these flying reptiles began to prey on each other was there any check to their evolution and diversity of formation. The remains of some twenty different species have already been discovered, and this is indicative of hundreds, perhaps thousands, of diverse species of these strangely flying Pterosaurs.

A somewhat similar instance of early and perhaps general possession of the atmospheric field is afforded in the case of insects. Some peculiarity of ormation, perhaps the remnant of an original dorsal gill, gave them a structural organ capable of partly aiding them in leaping and of being modified into a membranous wing. But as in vertebrates so in insects, the field of air became in time so fully occupied, and the claimants for its food supply so numerous, that the less vigorous flyers or those adapted to specially terrestrial food, descended to the earth again, and in time lost the power, with the loss of the desire or need, of flight.

Some such fate seems to have overtaken the Pterosaurs. For the possession of the field of air was sharply contested by two other classes of animals, both of which had already stepped beyond the reptilian rank, and become hair-covered and warm-blooded, and one had gained the still more advanced condition of the mammalian organization. The contest between birds, bats, and Pterosaurs, was not alone a battle of flying carnivoræ, but a struggle for common supplies of food, in which the most vigorous flyer was most likely to win. As a probable consequence of this contest the birds have gained the diurnal possession of the air, the bats have become adapted to nocturnal food supplies, and the Pterosaurs have disappeared. They were probably vanquished in the fight, and gradually resumed terrestrial habits, or died out.

So far as we are aware the evolution of flying mammals was much later than that of birds. But the geological record is so incomplete that bats may have existed at a much earlier date than their discovered remains seem to show. They are found in Eocene deposits, and the bird remains yet found in earlier deposits are very few in number of instances or species. In considering the development of bat flight we are in the same line with those already examined. It is a development of the skin into a flying membrane. But in this case, in addition to the extension of this membrane between the fore and hind limbs, it is also extended between the fingers of the fore limbs. Possibly in the early flying efforts of bats the fingers were extended in such a manner as to render any accidental growth of skin between them an advantage. Differences in the locomotive habits, and in the foot development, of the progenitors of flying reptiles and flying mammals, may account for this greater extension of the flying membrane in the case of the latter. Naturally such an advantage was seized upon and improved by natural selection. The membrane extended to the tips of the fingers, the fingers themselves grew much longer, and in time the fore limb lost all its powers as a walking organ, but became developed into an efficient flying organ, Bats, by this specialization of their fore limbs, ceased to be quadrupeds, though they never became true bipeds. Sleep and flight constitute the measure of their existence.

Thus the development of all flying vertebrates other than birds pursued the same general course. It began with the extension of the skin of the sides, so as to serve for parachute motion; and ended with an extension of the fingers of the fore limbs, an extension of the membrane to the tips of these elongated fingers, and a flying motion of these limbs. In necessary connection with these were concomitant internal changes, the whole anatomy of the animal becoming adapted to its flying habits.

But in the development of bird flight quite a different mode of evolution appears. Flight is here attained not by a special adaptation of the skin, but of the dermal covering. This covering was probably not the hair in its full modern sense. It was a primitive derivation from the reptilian scale, which secondarily became the avian feather and the mammalian hair. The feather of the bird agrees with the scale of the reptile in being developed in little hillocks upon the skin. The hair of the mammal developed in closed follicles within the skin. There thus has been a specialization in both, with the production of a change in the terminal character of the feather and in the dermal origin of the hair.

The progenitors of birds were either land or tree dwelling reptiles; most probably the latter. We have seen the extreme improbability that any leaping motion from the earth developed into a flight. We have also seen how natural it is for animals to leap from the limbs of trees, and that, in several modern instances, a degree of aerial support has been thus developed. But in such a leaping motion it is highly probable that some animals would make other efforts for support in the air besides the horizontal extension of their limbs. The swimming motion is a very natural one. It is naturally adopted by all land animals which fall into the water, and the webbed feet of swimming birds have been produced by it in the same manner as the webbed fingers of flying bats. Let us now consider some early animal, so far advanced beyond the reptilian ranks as to have become warm blooded, and covered with the primitive form of hair, arboreal in its habits, and accustomed to make long leaps from limb to limb. It is by no means improbable that some such animals would seek to swim in the air. A rapid motion of the fore limbs could not but aid in keeping the body horizontal, and if these limbs were covered with thick hair this must aid in breaking the fall of the animal. Any such habit could have but one result. A thicker hairy covering of the fore limbs, and even of the whole body, would prove an advantage to the animal, and these thickly matted hairs would tend to spread laterally, precisely as we find in the tails of Flying Squirrels and Phalangers. A still further advantage would be gained were these hairs rough instead of smooth on their edges, so as to cling together, and prevent the air from passing between them.

Such a swimming motion, performed by the fore limbs principally,—the hind limbs being the leaping organs,—and aided by the lateral outgrowth, and the "felting" of rough edged hairs, would, from its inception, be more than a parachute motion. It would be incipient flight from the first, a swimming in the air. The essential advantages gained by longer and longer leaps must tend to preserve any favorable conditions of the hair, and we can readily conceive the rough edges of the hairs extending into interlocking feathery expansions. In fact it is not difficult to imagine the slow evolution of true feathers in this manner, since every incipient approach to the feather must prove advantageous to the animal in its aerial motion.

But every better adapted movement of the fore limbs must prove similarly advantageous. Not only any variation from hairs towards feathers would be advantageous, but also any variation from a swimming towards a flying movement of the fore limbs. Of course the process must have been a slow one. It was necessarily slow also in the case of the bat and the Pterodactyl. But in all these cases every increment of variation from leaping towards flying was advantageous, so that there was no hindrance to a continual evolution towards full powers of flight.

But the development of the fore limbs into feathered wings unfitted them more and more for walking organs. The slowly developing bird must have trusted more and more to its hind limbs for support. Its arboreal habit developed the toes of these limbs into grasping organs. The original quadruped in time became a true biped, with a foot specially adapted to grasp the rounded surfaces of the limbs of trees, and so changed in position as to fall under the centre of gravity of the body. Hairs became feathers, the bones of the fore limbs aborted in part and became wing bones, and the original tree leaping reptile became a flying bird.

We may close with a very brief further consideration. In the first place it is highly probable that only quite small animals first gained this flying habit. Considerable weight would hinder its development. But after it was once gained there would be no special hindrance to increase in size in the newly evolved species. Yet a very great increase in size would so greatly increase the muscular effort necessary to flight that the larger birds would most likely spend a considerable portion of their time upon the earth. And in many cases the increased weight which is apt to arise from diminution of muscular exercise might render a resumption of the flying habit impossible. Such birds would lose their aerial powers, and become true land bipeds. We may ascribe the land residence, and the aborted wings, of the Ostrich, Cassowary, &c., to some such secondary process of evolution. On the other hand, many virtually land birds have become so by an adaptation to food in the obtaining of which flight was no advantage. Organs not used soon lose their muscular vigor, their size decreases, and gradual abortion takes place, unless adaptation to some new function gives them a special development in this new direction, and checks their tendency to disappear.

II.

STONE IMPLEMENTS IN THE DRIFT.*

By Watson C. Holbrook.

Many stone implements have been found deeply buried in the clay and gravel of Whiteside county, Illinois. Mindful of the many sources of error, and fully conscious of the many grave and serious questions involved, I have endeavored to examine with care and attention every one of the finds. The first is a black chest spear head about five inches long found incased in a block of granular stalagmite. This specimen was found in a light-blue clay. Above this clay was an alluvial deposit about five feet thick. Some pre-historic man must have left his spear head in a cave or hid it in a fissure of rock. Layer after layer of stalagmite was found. The spear's head

* A. A. A. S., Cincinnati, 1881.