pretty completely cut off from one another, three animals, in parentage widely dissimilar, have arrived at dentitions of *rodent* type. Thus in Australia, a region practically wholly monopolised by marsupials, a marsupial, the Wombat, has a dentition very much like an ordinary placental rodent. In the island of Madagascar, which is, with the exception of a few mice, without indigenous rodents, a lemurine animal, the *Cheiromys* [Aye-aye], has a dentition modified in a similar direction; and elsewhere, scattered over the world, we have the ordinary rodents. In fact, three creatures, as widely different in parentage as they well could be, have been modified by natural selection until they have dentitions, not identical, but for practical purposes not unlike."

In one instance we think that Mr. Tomes has gone a little too far in his generalising proclivities, and this is with reference to the canine teeth, when we are told that "it would practically be very inconvenient to abolish the term canine, but it should be borne in mind that its significance is merely equivalent to *caniniform premolar*, and that in describing the dog's dentition we should be less liable to be misinterpreted were we to say that it has five premolars, of which the first is caniniform." This unwillingness to recognise the canine tooth as an element of the dental series makes Mr. Tomes, as do M. Milne-Edwards and some other naturalists, include the lower "canines" of the ruminant ungulata, and lemurs, with the incisors. This, however, is quite opposed to the well-supported doctrine that in placental mammals there are never more than three incisors in each side of each jaw, and if extended to its logical consequences must render it necessary that the lower incisors of all mammals should be termed *incisiform premolars*, a very awkward predicament. We all accept it as a fact that the definition of a "canine" tooth is not established upon so distinct a footing as a premolar and a molar, or an upper incisor; but any argument which attempts to annihilate its entity does away with the lower incisors also. In an animal like the Musk Deer (*Moschus moschiferus*), where the premolars are gradually reduced from behind forwards, how is it, it may be asked, that the upper canine tooth does not, if a premolar, participate in the reduction? Reversely it is immensely exaggerated in size.

Attention is drawn to an important fact recently arrived at by M. Pietkewickz, that, contrary to the statement of Goodsir, there are no traces, even in the youngest examples, of rudimentary upper incisors in the true Ruminantia.

There is another minor point in which we would differ from Mr. Tomes. Speaking of the Perissodactylate and Artiodactylate Ungulata, it is said that "the distinction between the two groups is strongly marked, if living animals alone be considered; but, as Prof. Huxley has pointed out, increasing knowledge of fossil forms is tending to break down the line of demarcation." Our experience is otherwise, and we cannot see between *Coryphodon* and *Anoplotherium* any nearer affinities than between the Tapir and the Hippopotamus. It is quite beyond our comprehension that an animal with the axis of the limb running through the middle of the median digit should be allied to a similar creature in which the axis runs between the third and fourth digits, except in times when no such special axis of support existed; that is, before the Ungulata came into existence as such.

In conclusion we cannot do better than recommend this valuable work by Mr. Tomes to students, not only to those who make the diseases of the teeth their special study, but also to others who are endeavouring to obtain reliable information on the comparative anatomy of these organs, which from their variations and complexity in different animals, have yielded and for a long time yet to come will continue to yield, so large a field for zoological investigation.

FORMATION OF RAINDROPS AND HAILSTONES[1]

When the particles of water or ice which constitute a cloud or fog are all of the same size, and the air in which they are sustained is at rest or is moving uniformly in one direction, then these particles can have no motion relatively to each other. The weight of the particles will cause them to descend through the air with

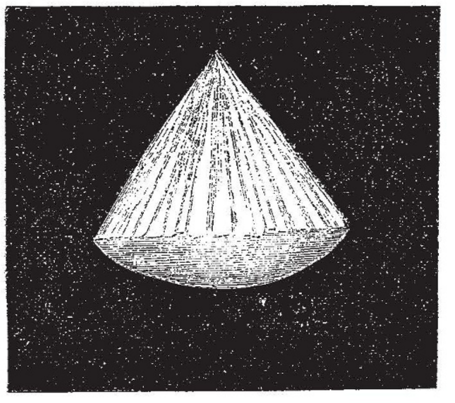

Fig. 1.—Perfect Hailstone.

velocities which depend on their diameters, and since they are all of the same size, they will all move with the same velocity.

Under these circumstances, therefore, the particles will not traverse the spaces which separate them, and there can be no aggregation so as to form raindrops or hailstones.

If, however, from circumstances to be presently considered, some of the particles of the cloud or fog attain a larger size than others, these will descend faster than the others, and will consequently overtake those immediately beneath them; with these they may combine so as to form still larger particles which will move with greater velocity, and more quickly overtaking the particles in front of them will add to their size at an increasing rate.

Under such circumstances, therefore, the cloud would

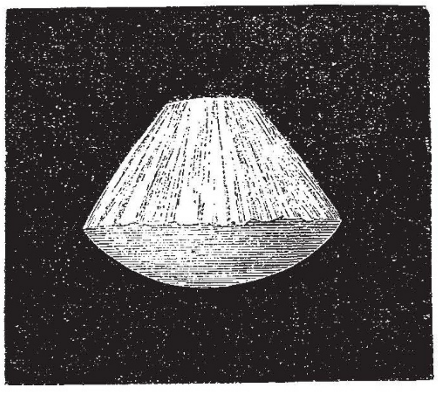

Fig. 2.—Broken Hailstone.

be converted into rain or hail according as the particles were water or ice.

The size of the drops from such a cloud would depend simply on the quantity of water suspended in the space swept through by the drop in its descent, that is to say,

[1] Abstract of paper "On the Manner in which Raindrops and Hailstones are Formed," by Prof. Osborne Reynolds, M.A., read at the Literary and Philosophical Society, Manchester.

on the density and thickness of the cloud below the point from which the drops started.

The author's object is to suggest that this is the actual way in which raindrops and hailstones are formed. He was first led to this conclusion from observing closely the structure of ordinary hailstones. Although to the casual observer hailstones may appear to have no particular shape except that of more or less imperfect spheres, on closer inspection they are seen all to partake more or less of a conical form with a rounded base like the sector of a sphere. In texture they have the appearance of an aggregation of minute particles of ice fitting closely together, but without any crystallisation such as that seen in the snow-flake, although the surface of the cone is striated, the striæ radiating from the vertex. Such a form and texture as this is exactly what would result if the stones were formed in the manner described above. When a particle which ultimately formed the vertex of the cone, started on its downward descent and encountered other particles on its lower face, they would adhere to it, however slightly. The mass, therefore, would grow in thickness downwards; and as some of the particles would strike the face so close to the edge that they would overhang, the lower face would continually grow broader, and a conical form be given to the mass above.

When found on the ground the hailstones are generally imperfect; and besides such bruises as may be accounted for by the fall, many of them appear to have been imperfect before reaching the ground. Such deformities, however, may be easily accounted for. The larger stones fall faster than those which are smaller, and consequently may overtake them in their descent; and then the smaller stones will stick to the larger and at once deform them. But besides the deformation caused by the presence of the smaller stone, the effect of the impact may be to impart a rotary motion to the stone, so that now it will no longer continue to grow in the same manner as before. Hence we have causes for almost any irregularities of form in the ordinary hailstone.

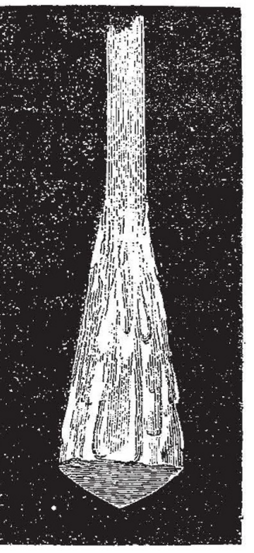

Fig. 3.—Imitation in Plaster of Paris.

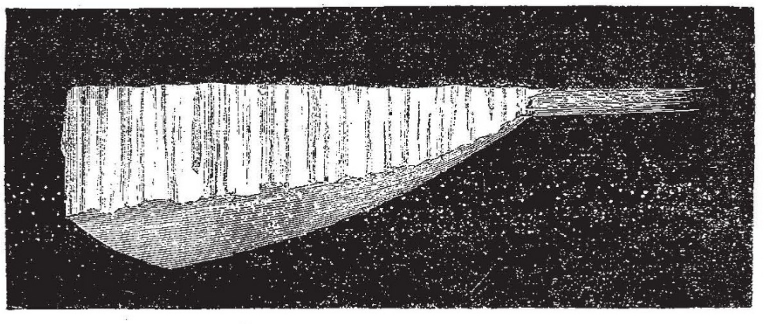

Fig 4.—Imitation in Plaster of Paris.

It appears from the numerous accounts which have been published that occasionally hailstones are found whose form is altogether different from that described above. These, however, are exceptional, and to whatever causes they may owe their peculiarities these causes cannot affect the stones to which reference is here made.

Again, on careful examination it is seen that the ordinary hailstones are denser and firmer towards their bases or spherical sides than near the vertex of the cone, which latter often appears to have broken off in the descent. This also is exactly what would result from the manner of formation described above. When the particle first starts it will be moving slowly, and the force with which the particles impinge upon it will be slight, and, consequently, its texture loose; as, however, it grows in size and its velocity increases, it will strike the particles it overtakes with greater force, and so drive them into a more compact mass. If the velocity were sufficient, the particles would strike with sufficient force to adhere as solid ice, and this appears t be the case when the stones become large, as large as a walnut, for instance.

An idea of the effect of the suspended particles on being overtaken by the stone, may be formed from the action of the particles of sand in Mr. Tilghman's sand-blast, used for cutting glass. The two cases are essentially the same, the only difference being that the hailstone is moving through the air, whereas in the case of the sand-blast, the object which corresponds to the stone is fixed, and the sand is blown against it.

By this sand-blast the finest particles of sand are made to indent the hardest material, such as quartz or hard steel; so that the actual intensity of the pressure between the surface of the particles of sand and that of the object they strike, must be enormous. And yet the velocity of the blast is not so much greater than that at which a good-sized hailstone descends. It is easy to conceive, therefore, that the force of the impact of the suspended particles of ice if not much below the temperature of freezing on a large hailstone, would drive them together so as to form solid ice. For the effect of squeezing two particles of ice together, is to cause them to thaw at the surface of contact, and as soon as the pressure is relieved they freeze again, and hence their adhesion.

It is then shown that hailstones, such as those described, can neither be formed by the freezing of rain-drops, nor by the condensation of vapour on a nucleus of ice; and that it is impossible that the particles of ice can have been drawn together by electrical attraction—their conical shape, and the increase in their density towards their thicker sides clearly showing that the particles have aggregated from one direction, and with an increasing force as the size of the stone has increased.

The possibility of making artificial stones is thus considered:—If a stream of frozen fog were driven against any small object, then the frozen particles should accumulate on the object in a mass resembling a hailstone. Not seeing his way to obtain such a stream of frozen fog, the author thought it might be worth while to try the effect of blowing very finely powdered plaster of Paris. He therefore introduced a stream of this material into a jet of steam, issuing freely into the air (which he hoped would moisten the powdered plaster sufficiently to cause it to set firmly into whatever form it collected). The jet was directed against a splinter of wood.

In this way masses of plaster very closely resembling hailstones were obtained. They were all more or less conical, with their bases facing the jet. But as might be expected, the angles of the cones were all smaller than those of the hailstones. Two of these figures are shown in the sketches annexed:

The striæ were strongly marked, and exactly resembled those of the hailstone. The bases also were rounded. They were somewhat steeper than those of the hailstone; but this was clearly due to the want of sufficient cohesive power on the part of the plaster. It was not sufficiently wet. Owing to this cause also it was not possible to preserve the lumps when they were formed, as the least shake caused them to tumble in pieces.

Similar masses were also obtained by blowing the vapour of naphthaline, but these were also very fragile. Whereupon it is remarked:—At ordinary temperatures the powdered naphthaline does not adhere like ice when pressed into a lump. No doubt at very low temperatures ice would behave in the same way, that is to say, the particles would not adhere from the force of impact. Hence it would seem probable that for hailstones to be formed, the temperature of the cloud must not be much below freezing-point.

That the effect of the temperature of the cloud exercises great influence on the character of the hailstones cannot be doubted. And if, as has been suggested by M. L. Dufour, the particles will sometimes remain fluid, even when the temperature is as low as 0° F., it is clear that as they are swept up by a falling stone, they may freeze into homogeneous ice either in a laminated or crystalline form.

The author then proceeds to show that raindrops are probably formed in the same way as hailstones; that although the raindrops have no structural peculiarities like the hailstones, the aggregation of the particles of water by the descent of the drop through the cloud is the only explanation which will account for them. He shows that, as Mr. Baxendell had previously pointed out, the amount of vapour which a cold drop could condense before it becomes as warm as the vapour would be inappreciable when compared with the size of the drop, and since, in order that there might be condensation, the air must be warmer than the drop, the drop could not part with its heat to the air. He also shows that during the time of descent of a large drop, the heat lost by radiation would not account for the condensation of sufficient vapour to make any appreciable difference in the size of the drop. Whereas if we suppose all the vapour which a body of saturated air at 60° F. would contain over and above what it would contain at 32° to be changed into a fog or cloud; then if a particle, after commencing to descend, aggregated to itself all the water suspended in the volume of air through which it swept, the diameter of the drop after passing through 2,000 feet would be more than an eighth of an inch, and after passing through 4,000 feet a quarter of an inch, and so on. So that in passing through 8,000 feet of such cloud, it would acquire a diameter of half an inch.

The fact that raindrops never attain the size of large hailstones is explained as being due to the mobility in the case of large drops of the surface tension of the water, by which alone the drop retains its form, to withstand the disturbing force of the air rushing past; when the drop reaches a certain size, therefore, it is blown in pieces like the water from a fountain.

The origin of drops and stones is then discussed—why some of the particles in a cloud should be larger than the others, as it is necessary for them to be in order that they may commence a more rapid descent. A cloud does not always rain; and hence it would seem that in their normal condition the particles of a cloud are all of the same size and have no internal motion, and that the variation of size is due to some irregularity or disturbance in the cloud.

Such irregularity would result when a cloud is cooling by radiation from its upper surface. The particles on the top of the cloud being more exposed would radiate faster than those below them and hence they would condense more vapour and grow more rapidly in size. They would therefore descend and leave other particles to form the top of the cloud. In this way we should have in embryo a continuous succession of drops.

Eddies in the cloud also form another possible cause of the origin of drops and stones.

D'ALBERTIS'S EXPEDITION UP THE FLY RIVER, NEW GUINEA

RECENT letters from Sydney announce the successful results of Signor L. M. D'Albertis's expedition up the Fly River, and that he was shortly expected back in Sydney.

The following letter from him to Dr. George Bennett has been published in the Sydney newspapers of October 13:—

"DEAR DOCTOR,—I have written a letter to the Committee, necessarily very brief, as I have but little time and a very scanty supply of paper. I am satisfied with the collection I have made, not for the number, but for the quality. I have four species of birds of paradise (*Paradisea*), the *P. raggiana*, the *P. apoda*, the twelve-wired bird of paradise (*Seleucides alba*), the king bird of paradise (*Cincinurus regius*), and the rifle bird (*Epimachus magnificus*). I got a perfect adult specimen of a cassowary, which I think is *Casuarius bicarunculatus*; also the *Dasyptilus pecqueti*, a new genus of *Ptilotis*, and a splendid new species of *Gracula*, and several other small but very interesting birds. I have seen many birds which are not included in the avifauna of New Guinea, as the *Pelecanus conspicillatus*, the Jabiru (*Mycteria australis*) and the pygmy goose (*Nettapus pulchellus*). Among my fishes I have some fine and large species. Of reptiles I have very few except a water snake, which I hope will be something extraordinarily new. Among my insects I have some fine Coleoptera, but the season was not very favourable for them. I expect to have about five hundred species of dried plants and between twenty and thirty of living plants, collected far in the interior, many of which I did not get afterwards. I hope Mr. C. Moore will be satisfied, as I have some fine crotons and palms among them, also some ferns with variegated leaves, orchids, and several other plants with variegated or spotted foliage, &c., from the very centre of New Guinea. I hope Mr. Moore has sent to Somerset some Wardian cases, so that the plants may not be destroyed by the sea breezes during the passage to Sydney. I much regret that I cannot send you any specimens, but I have not a box to pack them