and by O. T. Sherman (present by invitation), on personality in the measures of the diameter of Venus: in mathematics, by S. Newcomb, on the theory of errors of observation, and probable results: in physics, by S. Newcomb, on the use of the word "light"; by W. H. Brewer, on the subsidence of particles in liquids; and by H. A. Rowland, on a new photograph of the solar spectrum: in meteorology, by E. Loomis, on the reduction of barometric observations to sea-level: in geology, by T. S. Hunt, on the Animikie rocks of Lake Superior; by J. D. Dana, on the stratified drift of the New Haven region; by B. Silliman, on the mineralogy and lithology of the Bodie mining district; and by J. S. Newberry, on the ancient glaciation of North America: in chemistry, by W. Gibbs, on phospho-vanadates, arsenio-vanadates, and antimonio-vanadates, and on the existence of new acids of phosphorus: in physiological chemistry, by R. H. Chittenden (present by invitation), on new primary cleavage forms of albuminous matter: in palæontology, by J. Hall, on the Pectinidæ and Aviculidæ of the Devonian system; and by O. C. Marsh, on the affinities of the dinosaurian reptiles: and in anthropology, by A. G. Bell, on the formation of a deaf variety of the human race; and by J. W. Powell, on marriage institutions in tribal society.

The report of the Committee on Glucose, appointed by the President in conformity with a request from the Government, was accepted by the Academy, and will be transmitted to Congress with the President's report. This will also embody the proceedings of recent meetings of the Academy, the report of the Committee on Alcohol, and that on the eclipse of the sun, together with the thanks of the Academy to the Secretary of the Navy and the officers of the *Hartford* for their cooperation in the expedition to Caroline Island. It will also include an expression of the approval of the Academy of the efforts now making to secure a system of uniform time.

The next stated session of the Academy will be held in Washington in April next, and it is probable that the following mid-year session will be held in Cambridge.

RIPPLE-MARKS[1]

IN the first series of experiments a cylindrical vessel, like a flat bath, with upright sides, was placed on a table, which was free to turn about a vertical axis. Some fine sand was strewn over the bottom to a depth of about an inch, and water was poured in until it stood three inches deep over the sand. It was found that rotational oscillation with a jerking motion of small amplitude gave rise almost immediately to beautiful radial ripples all round the bath. If the jerks were of small amplitude the ripples were small, and if larger they were larger. The radiating ripples began first to appear at the outer margin of the bath and grew inwards; but the growth stopped after they had extended to a certain distance. If the jerking motion was violent, ripples were not formed near the circumference, and they only began at some distance inwards.

An analysis of the observations was made on the hypothesis that the water remained still, when the bath oscillated with a simple harmonic motion. The problem was to find whether λ, the wave-length of ripple (in inches) was directly proportional to v, the maximum velocity of the water relatively to the bottom during the oscillatory motion; also to find the values of v_1 and v_2, the least and greatest velocities of the water compatible with the formation of ripple-mark.

It appears that, for the particular sand used, v_1 is half a foot per second, and v_2 a foot per second; and that the wave-length of ripple, λ, is $\cdot 00245 v$ when v is measured in inches per minute. The several results were as fairly consistent with one another as could be expected. The hypothesis that the water as a whole executes a simple harmonic oscillation relatively to the bottom is not, however, exact, and does not give the maximum velocity of the water in contact with the sand relatively thereto. The quantity called v is not in reality the maximum velocity of the water in contact with the bottom relatively thereto, but it is 6·283 times the amplitude multiplied by the frequency. Thus we cannot conclude that a current of half a foot per second is just sufficient to stir the sand. In the state of oscillation corresponding to v, it is probable that part of the water at the bottom is moving with a velocity much greater than half a foot per second relatively to the sand.

[1] "On the Formation of Ripple-mark in Sand." Abstract of a paper by G. H. Darwin, F.R.S., Plumian Professor and Fellow of Trinity College, Cambridge, read before the Royal Society on November 22, 1883.

It was after making these experiments that what appears to be the key-note of the whole phenomenon was discovered.

A series of ripples extending inwards for some distance having been made by oscillation, and the water having come to rest, the bath was turned slowly and nearly uniformly round. The uniform current flattened the tops of the ripples, but made the lee-side steeper.

It was conjectured that there would be eddies or vortices on the lee-side, and in fact minute particles lying on the surface of the sand were observed to climb up the lee-slope of the ripples apparently *against* stream. This proved conclusively the existence of the suspected vortices.

If when the bath was at rest a sudden motion was given in one direction, the sand on the lee-side of each ripple was observed to be churned up by a vortex. By giving a short and sudden motion the direct stream might be seen to pile up the sand on the weather-side and the vortex to pile it up on the lee-side. The sand so displaced formed two little parallel ridges, that on the lee-side being a little below the crest of the ripple-mark.

For the purpose of examining the vortices a glass tube was drawn out to a fine point and fitted at the other end with a short piece of india-rubber tube. With this a drop of ink could be squirted out at the bottom of the water. This method was adopted in all subsequent observations, and it proved very valuable. It may be worth mentioning that common ink, which is heavier than water, was better than aniline dye.

A drop of ink was placed in the furrow between two ripples; as soon as the continuous stream passed, the ink was parted into two portions, one being sucked back apparently against stream up the lee-side of the ripple-mark, and the other being carried by the direct stream towards the crest. These points being settled, it remained to discover how the vortices were arranged which undoubtedly must exist in the oscillatory formation of regular ripples.

The observations were made in two ways, first with a glass trough so arranged that it could be gently rocked by hand, and secondly with an oscillating sheet of glass.

When the trough is half filled with water, and sand is sprinkled on the bottom, it is easy to obtain admirable ripple-marks by gently rocking the trough.

When a very small quantity of sand is sprinkled in and the rocking begins, the sand dances backwards and forwards on the bottom, the grains rolling as they go.

Very shortly the sand begins to aggregate into irregular little flocculent masses, the appearance being something like that of curdling milk. The position of the masses seems to be solely determined by the friction of the sand on the bottom, and as soon as a grain sticks, it thereby increases the friction at that place.

The aggregations gradually become elongated and rearrange themselves. As soon as the formation is definite enough to make the measurement of the wave-length possible, it is found that the wave-length is about one-half of what it becomes in the ultimate formation.

Some of the elongated patches disappear, and others fuse together and form ridges, the ridges then become straighter, and finally a regular ripple-mark is formed, with the wave-length double that in the initial stage.

If, after the formation of regular ripples, and the deposition of a drop of ink at the bottom, a very gentle oscillation be started, the layer of ink on the crest of a ripple becomes thicker and thinner alternately, swaying backwards and forwards; then a little tail of ink rises from the crest, and the point of growth oscillates on each side of the crest; the end of the tail flips backwards and forwards. Next the end of the tail spreads out laterally on each side, so that a sort of mushroom of ink is formed, the stalk of the mushroom dancing to and fro. The height of the mushroom is generally less than a millimetre.

The elongated hollows under the mushroom are the centres of vortices, and the stem is the upward current. If the ink be thick, these spaces are clouded, and the appearance is simply that of an alternate thickening and thinning of the ink on the crest. The oscillations being still gentle, but not so gentle as at first, streams of ink from the two mushrooms on adjacent crests creep down the two slopes into the furrow between the adjacent ridges, and where they meet a column of ink begins to rise from the part of the water whose mean position is in the centre of the furrow.

The column is wavy, and the appearance is strikingly like that of smoke rising from a fire in still air.

The column ascends to a height of some five, ten, or perhaps twenty times the height of the ripple-marks, according to the violence of the agitation. It broadens out at the top on each side, and spreads out into a cloud, until the appearance is exactly like pictures of a volcano in violent eruption; but the broad flat cloud dances to and fro relatively to the ascending column. The ink continues to spread out laterally and begins to fall on each side. In this stage if the ink is not thick it is often very like a palm-tree, and for the sake of a name this appearance is called an ink tree. The branches (as it were) then fall on each side, and the appearance becomes like that of a beech tree, or sometimes of an umbrella. The branches reach the ground, and then creep inwards towards the stem, and the ink, which formed the branches, is sometimes seen ascending again in a wavy stream parallel to the stem.

Perhaps a dozen or twenty oscillations are requisite for making the ink go through the changes from the first growth of the tree.

The descending column of a pair of trees comes down on to the top of the mushroom, but the successful manufacture of the tree necessitates an oscillation of sufficient violence to render the simultaneous observation of the mushroom very difficult.

With violent oscillation, when the stem of the tree is much convoluted, it cannot be asserted that the mushroom vortices exist, and the author is inclined to believe them to be then evanescent.

Each side of the ink tree is clearly a vortex, and the stem is the dividing line between a pair, along which each vortex contributes its share to the ascending column of fluid. The vortex in half the tree is clearly in the first place generated by the friction of the vortex in its correlated mushroom, and is of course endued with the opposite rotation. The ascending stem of the tree is a swift current, but over the mushroom the descending current is slow until close to the mushroom, when the current is seen to be impelled by pulses.

If the adjoining crests are of unequal height, the stem of the tree is thrown over sideways away from the higher crest; and indeed it requires care to make the growth quite straight. The ink in the stem ascends with a series of pulses, and it is clear that there is a pumping action going on which renders the motion of each vortex intermittent, and the two halves of the tree are pumped alternately.

The amount of curvature in the stem of the tree depends on the amplitude of the oscillation of the water.

The ink is propagated along the convolutions of the stem of the ink tree, but the convolutions are themselves propagated upwards, and each convolution corresponds to one oscillation. The motion of the ink along the convolutions soon becomes slow, but the convolutions become broader and closer. Thus the upper part of the tree is often seen to be most delicately shaded by a series of nearly equidistant black lines.

In the transition from the mushroom stage to the tree stage it appeared that it was very frequent that only half the ink tree was formed.

If the agitation is very gentle, the sand on the crests of the ripple-marks is just moved to and fro; with slightly more amplitude, the dance is larger, and particles or visible objects, such as minute air-bubbles in the furrow also dance, but with less amplitude than those on the crests. The dance is not a simple harmonic motion like that of the main body of the water relatively to the bottom, but the particles dash from one elongation to the other, pause there, and then dash back again.

As the amplitude further increases, the furrows are completely scoured out, and the sand on the crests is dashed to and fro, forming a spray of sand dancing between two limits. With violent agitation, this dance must have an amplitude of more than half a wave-length. If the agitation be allowed to subside, the dance subsides, and when the water is still the ripple-mark is left symmetrical on both sides. With extremely violent oscillation, all the water becomes filled with flying dust, and it is no longer possible to see what is happening. This seems to be the condition when the agitation is too strong for the formation of ripple-mark. It is probable that the rush of water sweeps away the existing ripple-mark, and there is then no longer anything to produce a systematic arrangement of vortices.

The author illustrates the dance of the vortices by a succession of figures.

It is hardly possible to explain the series of changes in words, but we may here state that the mechanism by which the ripples are made and maintained depends on the fact that the upward current of a pair of vortices lingers over the ripple crest, and then darts across with extreme rapidity to the adjoining crest. Thus each pair of vortices is associated with two crests, spending nearly half the time over one, and half the time over the other.

As above stated, it has seemed that only one of each pair of tree vortices is set up at first, and the author is disposed to regard this as the transitional state from the mode of oscillation, which produces the half wave-length with small height of ripple-crest, to the fundamental wave-length with considerable height.

The results of the observations may be summarised as follows:—

The formation of irregular ripple-marks or dunes by a current is due to the vortex which exists on the lee of any superficial inequality of the bottom; the direct current carries the sand up the weather slope and the vortex up the lee slope. Thus any existing inequalities are increased, and the surface of sand becomes mottled over with irregular dunes. The velocity of the water must be greater than one limit and less than another, the limiting velocities being dependent on the average size and density of the particles. Existing regular ripple-mark is maintained by a current passing over it perpendicular to the ridges. A slight change in form ensues, the weather slope becoming less steep and the lee slope steeper. The ridges are also slowly displaced to leeward. The regular ripple-mark may also thus be somewhat prolonged, so that although a uniform current probably cannot form regular ripple-mark, yet it may increase the area over which it is to be found.

Regular ripple-mark is formed by water which oscillates relatively to the bottom. A pair of vortices, or in some cases four vortices, are established in the water; each set of vortices corresponds to a single ripple-crest and the vortices oscillate about a mean position, changing their shapes and intensities periodically, but not with a simple harmonic motion.

The successive changes in the vortex motion, whilst ripple-mark is being established, and when the amplitude of oscillation over existing ripple-mark varies, are complex, and we must refer the reader to the original paper for an account of the phenomena.

It is important to note that when once a fairly regular ripple-mark is established, a wide variability of amplitude in the oscillation is consistent with its maintenance or increase. No explanation of ripple-making can be deemed satisfactory which does not satisfy this condition.

The last section gives some account of the valuable papers of MM. Hunt,[1] Casimir de Candolle,[2] and Forel[3] in this field. The author agrees in the main with these observers, but considers that some of their conclusions are open to criticism.

He next remarks that it is not easy to understand precisely the mode in which the oscillation of the water over the undulating bottom gives rise to vortices, but that there are familiar instances in which nearly the same kind of fluid motion must occur.

In the mode of boat propulsion called sculling, the sailor places an oar with a flat blade through a rowlock in the stern of the boat, and, keeping the handle high above the rowlock, waves the oar backwards and forwards with an alternate inclination of the blade in one direction and the other. This action generates a stream of water sternwards. The manner in which the blade meets the water is closely similar to that in which the slopes of two ripple-marks alternately meet the oscillating water; the sternward current in one case, and the upward current in the other are due to similar causes. We may feel confident that in sculling, a pair of vortices are formed with axes vertical, and that the dividing line between them is sinuous. The motion of a fish's tail gives rise to a similar rearward current in almost the same way. These instances may help us to realise the ripple-making vortices.

Lord Rayleigh has considered the problem involved in the oscillations of a layer of vertically moving fluid separating two uniform streams.[4] At the meeting of the British Association at Swansea in 1880 Sir William Thomson read a paper discussing

1 "On the Formation of Ripple-mark." *Proc. Roy. Soc.*, April 20, 1882 vol. xxxiv. p. 1.

2 *Archives des Sciences Physiques et Naturelles Genève*, No. 3. vol. ix., March 15, 1883. "Rides formées," &c.

3 "Les Rides de Fond." *Archives des Sciences Physiques et Naturelles Genève*, July 15, 1883.

4 "On the Stability or Instability of certain Fluid Motions." *Proc. Lond. Math. Soc.* (February 12, 1880), vol. xi. p. 57.

Lord Rayleigh's problem.[1] He showed that, in a certain case in which the analytical solution leads to an infinite value, there are waves in the continuous streams in diametrically opposite phases, and that the vortical stratum consists of a series of oval vortices. The uniform current flowing over existing ripple-mark exhibits almost a realisation of this mode of motion, one of the streams of fluid being replaced by the sandy undulations. The same kind of motion must exist in air when a gust of wind blows a shallow puddle into standing ripples.

It seems probable that what is called a mackerel sky is an evidence of a mode of motion also closely similar to that described by Sir William Thomson. M. de Candolle's suggestion that cirrus is aërial ripple-mark may then be regarded as substantially correct.

If two horizontal currents of fluid exist one above the other, the layer of transition from one to the other is dynamically unstable, but it is probable that if a series of vortices be interpolated, so as to form friction rollers as it were, it becomes stable. It is likely that in air a mode of motion would be set up by friction, which in frictionless fluid would be stable.

The formation of clouds is probably due to the saturation with moisture of one current and the coldness of the other.

The direction of striation and velocity of translation of mackerel clouds require consideration according to this theory.

It appears that if a mackerel sky be formed beween two aërial currents, the striations are parallel to that direction in which the two currents have equal component velocities, and the component velocity of the clouds parallel to the striations is equal to the component velocity of either current in the same direction.

The resultant velocity of the clouds is equal to a half of the resultant velocity of the two currents, and the component velocity of the striations perpendicular to themselves is the mean of the components of velocity of the two currents in the same direction.

The account which is given in this paper of the formation of ripple-marks shows it to be due to a complex arrangement of vortices. The difficulty of observation is considerable, and perhaps some of the conclusions arrived at may require modification. It is to be hoped that other experimenters may be induced to examine the question.

The reader is referred to the original for the figures, which are necessary to an adequate explanation of the phenomena and conclusions.

NOTE ON DEAFNESS IN WHITE CATS[2]

THIS curious occurrence has long been a matter of interest to me, originally because cats have always been very favourite pets in my household, and still more because the occurrence amongst them of deafness was used by Mr. Darwin in his first edition of "Animals and Plants under Domestication" as an illustration of correlated variability. He was under the impression that white cats with blue eyes were invariably deaf.

I had collected a number of observations which I had personally made, and I found that some white cats were deaf which had the ordinary yellow eyes, and that some white cats with blue eyes could hear perfectly well. I have never heard of deafness in any but a white cat, and all the deaf white cats I had personally examined were males. Therefore, in NATURE, 1873, I published a brief note pointing out Mr. Darwin's error. In his second edition Mr. Darwin established two cases of deafness in female white cats, so that the conclusions of both of us were upset, and this wholesale destruction of theories has been completed by the birth in one of my feline families of a white kitten, female, with perfectly yellow eyes, and absolutely deaf. She lived with us for two years, and her misfortune was quite permanent. My conclusions from the facts observed by myself now may be formulated in this way, that congenital deafness is not known to occur in any animal but the cat, though I am not quite sure but that one white mouse I had some years ago was deaf, and that no cats but those entirely white are ever deaf. As female cats are far more common than males (and this seems to be true of white cats as well as those of other colours), and as I have known only one deaf female cat for some twenty deaf males, I think I may assume that deafness is more common among males than among females. The colour of the eyes has evidently nothing to do with the deafness, though it has with the colour of the fur, and seems to be dependent on the same process—an arrest of development. The eyes of nearly all kittens are blue for some weeks after birth, and the same cause which arrests the pigmentation of the fur arrests in a very much smaller number the pigmentary growth in the eye. I have been told of two cases of complete absence of pigment in the eyes of two cats (albinism) as is seen so commonly in rabbits, guinea-pigs, rats, and mice, but I have not been able properly to authenticate them. These cats were said to be not deaf.

In 1872 I obtained a cat from Hertfordshire as an example of the polydactilism which is very common there, and when he arrived I found that he was white, that he had one eye a bright blue and the other a bright yellow, and that he was profoundly deaf. He was by far the most interesting cat I have ever possessed, and must be well remembered by many members of this Society who have favoured my house with their presence as "Old Pudge," possessed of all the feline virtues, and many of a more human type—and free from vice of every kind. He lived with us for eleven years, and died last winter of peritonitis. Whilst living with us we made many observations concerning his deafness, and I easily determined that it was purely tympanic—that is, he was deaf to impressions conveyed through the air, but his intelligence could be reached by impressions conveyed through solid media. When I wanted him to come to me I gave a peculiar sharp stamp on the floor, and he immediately responded to the signal, even if he was on a chair or table. It is very remarkable that this congenital deafness is in no way associated in the cat with mutism. Human deaf-mutes generally are those in whom deafness is cochlear as well as tympanic, and the result of such disease as scarlet fever in very early life. One other peculiarity he had is that for about four years he suffered from occasional fits of epilepsy of a very severe kind. They came on always during his sleep, and for their first indication had the painful peculiarity that the cat seized the tip of his tail and bit it off, and in this way his tail was shortened considerably. Every kind of white animal I have kept as a pet has been the subject of epilepsy, and the association is suggestive when we are told, as I have been frequently, that the disease is unknown amongst negroes.

I sent the body of my old cat to Prof. Flower for the purpose of having an investigation made into the cause of his deafness. Prof. Flower had a most careful investigation of the condition of his ears made by two most competent investigators—Dr. Cumberbatch and Dr. Heneage Gibbs. The result, briefly stated, is that all the structures in the ears were normal save the tympanic membranes, in which there were triangular gaps extending from the roof to just below the centre, the bases of the gaps being directed upwards, and their anterior side being formed by the handles of the mallei. The gaps appeared to be congenital, and were quite symmetrical; all the other apparatus of the ears was normal, and the auditory nerves were of normal size and structure.

The only congenital defect known in the human tympanum is a very minute aperture, of rare occurrence, and due to the patency of the fissure of Rivinus. The tympanic deficiency in the white cat seems to be in no way associated with this form of arrest.

The results of the observation are interesting, though the subject may perhaps be regarded as trivial, as by it the point raised by Mr. Darwin is finally established. It really is a case, and a very well marked one, of correlated variability, and its great interest is that the three structures affected—the fur, the iris, and the tympanic membrane—have a common origin from the epiblast. Had the defects observed in this cat been cochlear, the difficulty of understanding them would have been very great, as the structures of the internal ear arise from the mesoblast, according to Balfour. LAWSON TAIT

[1] NATURE, November 11, 1880, pp. 45-46, and see correction on p. 70.

[2] Read before the Birmingham Philosophical Society, October 11.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—The recent recommendations of the General Board of Studies have all been passed. These include the appointment of a Professor of Pathology next term, of Readers in several subjects, including Comparative Philology and Botany, of University Lecturers in connection with Special Boards, including Medicine (four), Mathematics (five), Biology and Geology (six), History and Archæology (five), Moral Science (one),