

adopting the Kew methods of magnetic investigation. The completeness of the photographic process is shown by the fact, that of 175,344 hourly positions which should have been recorded in the interval under notice, there were only 1497 failures from all causes whatsoever; and even of these few a considerable portion is shown to be due to the employment of the instruments in other experimental investigations. The paper contains a full statement of the processes of tabulation from the photograms, and of the different stages of reduction through which the tabular results were passed, for the purpose of deriving from them the facts connected with the lunar influence on the terrestrial magnetic elements. A lunar-diurnal variation is shown to exist in each of these elements,—of very small amount, but having peculiar and well-marked systematic characteristics. It is further shown that these characteristics present a similarity and accordance, which it is impossible to regard as accidental, with the results obtained at several other and widely-separated localities in the middle latitudes of both hemispheres, as for example at Hobarton, Toronto, Philadelphia, Pekin, and the Cape of Good Hope. A magnetic variation shown to be thus obviously dependent upon the moon's position relatively to the terrestrial meridian, and agreeing in its principal features in such various localities, is urged by the author as being ascribable with great probability to the direct magnetic action of the moon, made sensible at the surface of the earth through the production of phenomena which, in the present state of our knowledge as regards the magnetism both of the earth and of the moon, it is as yet difficult wholly to explain, but which are likely to lead to a considerable advance of our knowledge in both these respects.

The further prosecution of the investigation, both at Kew and elsewhere, is recommended as highly deserving the attention of those who occupy themselves in the pursuits of inductive philosophy.

COMMUNICATIONS RECEIVED SINCE THE END OF THE SESSION.

- I. "On the Congelation of Animals." By JOHN DAVY, M.D., F.R.S., &c. Received July 19, 1866.

In a very interesting and elaborate paper by M. Puget, entitled "*Sur la Congélation des Animaux*," published in the '*Journal de l'Anatomie et de la Physiologie*,' the Number for January and February of this year, he refers to a statement of mine, made many years ago*, that the leech may be frozen without loss of life. The experiments which he has instituted, and which appear to have been conducted with great care, have led him to an opposite conclusion, viz. that congelation is not only fatal to the leech, but to animals generally, without a single exception. He considers the cause of death, the *vera causa*, to use his own words, to be an altered condition of the blood. In consequence of this statement, I thought it right

* *Recherches*, Physiol. and Anat. ii. p. 121.

to repeat the experiments on the leech, and to extend them to some other animals. They were begun at Oxford in May, in the laboratory of Professor Rolleston, with the kind assistance of Mr. Edward Chapman and Mr. Robertson; and since then, in the following month, they have been continued at home in Westmoreland.

At Oxford the trials were made on leeches and frogs; at home, on these animals, and on the toad and some insects. The freezing mixture was made of pounded ice and common salt; the temperature by it was commonly reduced to below 10° Fahr., or at times so low as 2° or 3° . The results obtained were briefly the following:—

1. A leech was exposed to the mixture in a small glass tube just large enough to hold it, using the tube for stirring the mixture. Taken out when perfectly rigid and hard, and gradually thawed, it showed when punctured a faint indication of irritability; there was a just perceptible contraction of the part punctured, the oral extremity, and nowhere else. It did not revive.

2. Another leech was similarly exposed, but for a shorter time. When divided by an incision, it was found not frozen throughout. When punctured, it showed marks of irritability in a slight degree stronger than the preceding: it soon died.

3. Two leeches were similarly treated at home, and for a somewhat longer time; the temperature reduced to 3° . These, when gradually thawed, one exposed to the air, the other left in the mixture, showed no marks of revival; but they retained a certain elasticity, so that when bent they shortly recovered their former attitude, after a manner somewhat resembling a vital movement; but inasmuch as they did not respond by the slightest contraction to puncture, it may be inferred that the movement was not vital. They resisted putrefaction for many days.

4. A frog in a thin glass vessel was kept in the mixture about a quarter of an hour. It was very rigid when taken out; thawed, no part on puncture afforded any indications of life; watched two or three hours it proved to be dead.

5. The heart of a frog, removed immediately after decapitation, whilst still pulsating, was subjected to the freezing mixture in a small glass tube. After having been frozen, on thawing it remained motionless, even when punctured. It had been kept in the mixture only a few minutes.

6. The inferior extremities of a frog kept extended by a bandage and thus introduced into a glass tube, were submerged in the mixture, the body of the frog being held in the warm hand; taken out after some minutes they were quite hard and motionless, whilst the body and upper extremities did not appear to be affected. It moved about, dragging the lower extremities as if they were dead. In about four hours it recovered the use of its femoral muscles; on the following day the use of the muscles of the legs; the day after it was able to bend and extend these limbs; but there was no proof that its feet had recovered sensibility. On the fourth day it was found dead.

7. The lower extremities of a large toad were immersed in direct contact with the mixture, the temperature falling to 3°. Gradually thawed, the parts showed no marks of life. This toad, which before the trial was in a dull state, afterward became almost torpid, and so continued until the following morning, when it was apparently dead: opened, the auricles were found feebly acting, ceasing after a few seconds*.

8. A similar experiment was made on the lower extremities of an active frog, and with a similar result, except that the vivacity of the animal was for a short time but little impaired: after four hours it was apparently dead; opened, its auricles contracted when punctured. It may be right to mention that, before exposing the toad and frog to the freezing mixture in direct contact, it was ascertained that the frog bore the immersion of its lower extremities in a saturated solution of common salt without any apparent loss of sensibility or motive power†.

9. The lower extremities of an active frog of a large size were wrapped in tin-foil, and together with one of its upper extremities not so wrapped, were kept in a freezing mixture about a quarter of an hour. The frozen parts in thawing showed no marks of life. The frog died in about three hours.

* This toad was a female which had shed her ova; the oviduct was still large; the stomach was distended with caterpillars, slugs, &c., seeming to show that there was no diseased state. It is noteworthy that the apertures of the cutaneous glands appeared to be closed; for when the animal was irritated there was no ejection of the acrid fluid, a circumstance I had before noticed in a female during the breeding-season, suggestive of a condition of surface favourable to the male in the generative act. When the tubercles were incised, they were found to contain the acrid fluid in plenty, and judging from its bitter taste, and the irritating effects of an extremely small portion applied to the tongue, not deficient in activity. The same state of the cuticular glands was found in another female toad killed by congelation, which had shed few of its ova, —this on the 23rd of June. It was of a lighter colour than usual. It was found likewise in two examined in July, in which some ova remained.

† The effect of immersion of the lower extremities of a frog in a saturated solution of common salt varies, I find, according to the length of time; if for a very few minutes, it is inconsiderable; if for many, it is well marked; and if much prolonged it is fatal. In one instance, after a quarter of an hour's immersion, the limbs seemed paralyzed, the animal in a state approaching to torpor: after having been well washed in fresh water it slowly recovered its activity, and the limbs their motive power and sensibility; the motive power first, their sensibility later; indeed not until the following morning, judging from the effects of puncture. After a longer immersion, with a fatal result, the limbs had become rigid and somewhat hard, especially the feet, as if their juices had been extracted by osmotic action. Opened after three hours, even the auricles were motionless, and this when punctured. The muscles of the limbs no longer showed a striated structure, whilst those of the upper extremities displayed this structure distinctly.

The toad with a thicker skin was found to bear the immersion of its extremities for a longer time; but the difference seemed to be only in degree; much longer continued, the same effects were produced, viz. rigidity, with loss of motion and sensibility, which (the immersion not being too long) were slowly recovered after fresh water ablution.

The blood-corpuscles, acted on by the same solution, underwent a change, contracting slightly, and acquiring a granular appearance, commencing in their nuclei.

10. A cockroach, a flesh-fly, and a minute insect, an ichneumon* (*Cælineus niger*?), confined together in a small glass tube, were kept some minutes in the mixture. Thawed, they were found all three dead.

These results, so far as the particular instances are concerned, are sufficiently confirmatory of M. Puget's, and on my mind they leave little doubt that his general proposition (his inference from his very numerous experiments) is correct, that congelation is fatal to animal life. It is hardly worth while to attempt to account for the different conclusion I had come to, that referred to by him relative to the leech, it being partly founded on the fact that leeches which had been enveloped in ice for many days were not thereby killed, and partly on witnessing some marks of vitality in leeches which were believed to have been artificially frozen, and which very soon after died.

Whilst admitting that congelation, thorough congelation of an animal is incompatible with life, the cause of death from congelation seems open to question, and more especially that assigned by M. Puget as the *vera causa*, a change in the blood, and chiefly in its corpuscles. That these corpuscles are changed by freezing in form and condition seems to be certain. Before seeing M. Puget's paper I had ascertained the fact, and not only that the corpuscles were changed, but also that the entire blood was to some extent altered, leading me at the time to ask whether some of the injurious effects of frost-bite may not be mainly owing to the freezing of the blood, and the changes in consequence in the corpuscles and in a less degree in the fibrin †; and since, in examining the blood of the animals exposed to the freezing mixture, I have had this confirmed; but the change in these instances was comparatively slight; even in those of the congealed limbs of the frogs and toad the majority of the corpuscles appeared little altered; some few seemed ruptured, some corrugated, and more contracted.

Judging from the effect of congelation on the heart of the frog in experiment No. 5, and from the effects of congelation partially produced, as in the extremities of the frog and toad, I would rather attribute the death to the freezing of the organs, not excluding the blood, than to the freezing of the blood alone; and I would ask, is not this view most in accordance with the pathology of the subject, with all that we know of frost-bite and its consequences in man, and with the results of Mr. Hunter's experiments on the local effects of congelation in animals—those on the ear of the rabbit and wattle of the cock ‡? and do not some even of M. Puget's results

* For the name of this insect I am indebted to Dr. Gray, F.R.S. It was selected on account of its minuteness: it weighed hardly $\frac{1}{100}$ of a grain; it seemed probable, on account of the minuteness of its vessels, that its fluids might escape congelation after the manner of fluids in capillary tubes, which may be reduced many degrees in temperature without being frozen.

† Physiological Researches, 1863, p. 371. See also Trans. Royal Society of Edinburgh, 1865, vol. xxiv. p. 26.

‡ Phil Trans. 1778, p. 34.

give it support, such as the opacity of the crystalline lens, he admitting that, were it possible for an animal to revive after complete congelation, it would be blind from cataract? Now, if the crystalline lens, if the blood-corpuscles suffer and undergo an appreciable change from congelation, it would be very remarkable indeed did not the brain and nerves, and the organs generally suffer from the same cause, and experience changes incompatible with life. In the instance of man, we know that a certain reduction of his temperature merely, not reaching to congelation, suffices to extinguish life*, and that in the instances of other animals, especially the hibernating and insects, a moderate reduction occasions torpor, ending in death if too prolonged. That the organs generally suffer from congelation M. Puget himself admits, as expressed in the subjoined paragraph†. I have found, too, that the muscles, after having been frozen, exhibit a marked change; thus, in one instance, that of a frog, in which, after decapitation, an upper and lower extremity were frozen, the muscles of these limbs, when thawed, compared with those which had not been frozen, showed a well-marked difference under the microscope. Thus, whilst in the latter the striated structure was very distinct, in the former it was no longer visible; and after a few hours, viz. on the following morning, whilst the unfrozen muscles had undergone no perceptible alteration, those which had been frozen had become of increased tenderness, yielding to a slight rending force, and breaking short, as if the coherence of the particles forming the fasciculi was greatly diminished.

II. "Letter to the President from Lieut.-Colonel WALKER, R.E., F.R.S., Superintendent of the Trigonometrical Survey of India."

Dehra Doon *via* Bombay, 31st May, 1866.

MY DEAR GENERAL,—Captain Basevi has just returned to my head quarters, on the close of the operations of his first field-season with the pendulums.

You will be glad to hear that his progress has on the whole been very satisfactory. At the outset he met with numerous difficulties; the vacuum apparatus was very troublesome, the air-pump constantly getting out of order, and the receiver as constantly leaking. It is very easy for philosophers to suggest improvements and refinements in the *modus operandi* of such operations, but it is not so easy to carry them out practically. Capt. Basevi has undergone a great amount of labour and anxiety, but he has successfully surmounted all his difficulties.

* Instances have occurred in the Lake District of persons who have perished on the hills from prolonged exposure to strong wind and rain, *storm-stricken*, in the language of the country.

† "... La congélation complète a même si profondément altéré les tissus de l'organisme que quand l'animal est tout à fait dégelé, son corps est flasque et mou, ses cristallins sont blancs et opaques, et souvent sa coloration est tout à fait altérée" (p. 24).