course no one taught the donkey to do this; but the quadruped gave the biped a practical lesson, from which I am not aware that they drew the abstract verbally formulated conclusion that reason may be exercised without rhetoric.

March 14 HENRY MUIRHEAD

I BELIEVE that instances of rats gnawing through water-pipes are frequent. Two have come to my knowledge during the past fortnight. The one instance occurred at the house of a gentleman near West Hartlepool; in the other case a large hole, $3\frac{1}{4}$ inches long, and varying from $\frac{5}{8}$ths of an inch to $1\frac{1}{8}$th inch in breadth, was gnawed in the fresh-water pipe of the screw-steamer *Mary Coverdale*. A portion of this pipe, containing the hole, was cut off, and is preserved by me; it is a stout leaden pipe, a quarter of an inch thick, and with a diameter of $2\frac{3}{8}$ inches. It is very doubtful whether there was any flaw before the hole was begun. R. MORTON MIDDLETON

West Hartlepool

Distribution of the Black Rat

PERHAPS some of the readers of NATURE may be able to throw some light on the present geographical range of the Black Rat (*Mus rattus*, L.). In the early part of 1877 some individuals of this species came on board the steamship *Lady Frances* either at Bombay or at Rangoon, but, as the captain believes, at the latter port. The animals multiplied on board the vessel, and in August last I had the pleasure of receiving from the ship a living specimen, which was at once forwarded to the Zoological Gardens in Regent's Park, where, I believe, it may still be seen. In a "Catalogue of the Mammals of the Sahara," by my friend, Canon Tristram, F.R.S. (*vide* "The Great Sahara," p. 385), the author states that the "Far el Kla," as the black rat is called by the Arabs, "still maintains its position" in the Algerian Sahara. And I was yesterday presented by Mr. F. Donald Thompson, of Seaton-Carew, with a skin of *Mus rattus* from New Zealand. This example, like those from Burmah, was brought over by a vessel (the *Trevelyan*) which loaded grain at Lyttelton, in the province of Canterbury, New Zealand, where the rats embarked. In August, 1878, Dr. Sclater, F.R.S., was good enough to inform me that "*Mus rattus* has rather an extensive range over Europe and Western Asia," and added, "I fear it would not be possible to state it very exactly." But it is evident that the range of the species is much wider, as it is known to occur in North Africa, British India, and New Zealand; and it is also said, by Prof. Bell and Mr. Macgillivray, to have been carried to America and the South Sea Islands by ships. I should be glad to have further evidence as to its occurrence in Burmah, and it would be also desirable to know if it is found in the Malay Archipelago, China, Japan, or Australia. Dr. Peters, of the Zoological Museum at Berlin, assured me, in June last, that the species was extremely rare, if not actually extinct, in Germany, and showed me the only specimen in the fine collection under his care—an old and faded skin from Hanover. The animal lingers in one old building at Stockton-on-Tees, and there is clearly a possibility of its being reintroduced in many seaport towns through the agency of ships.

West Hartlepool, March 11 R. MORTON MIDDLETON

The United States Fisheries

IN your review of the report of the United States Commission of Fish and Fisheries, you say you are of opinion there is almost no difference between *Salmo salar* and *Salmo quinnat*. My friend Prof. Baird sent me his report some time since, and also forwarded several thousand eggs of *Salmo quinnat* for experiment in the hatching tanks of the Southport Aquarium. The eggs hatched out remarkably well, a very small percentage only being lost, and have proved much more hardy and tenacious of life than any *Salmo salar* I ever had to do with, and very much easier to feed. *Salmo salar* have never done well except when fed on the minute red worms found on the mud in the beds of some rivers and streams (our supply was obtained from the Thames). *Salmo quinnat*, however, live well, and grow faster on the roe of fish (refuse from the fish market), such as whiting, than *S. salar* will on anything. From what I have seen of them I quite agree with Prof. Baird in his admiration of this member of the salmon family, and I share his surprise that it has attracted so little attention among English fish-culturists. It would certainly be a most valuable addition to our food-fishes, stronger, and apparently of more rapid growth than our native species. On the continent, and in New Zealand and other countries, it is most greedily sought after, and each season for several years past an agent has carried from America to France, Germany, and other countries, large consignments of the ova. In England, so far, it appears to have been quite neglected.

Hill Fold, Bolton, March 15 CHAS. L. JACKSON

Plovers in the Sandwich Islands

I CAN vouch for the truth of the visit of golden plovers to the Sandwich Islands mentioned by Prof. A. Newton in NATURE, vol. xix. p. 433. They are very numerous during the winter from November until March. I do not know the scientific name, but I have shot a great many on Oahu and Hawaii.

If it will help Mr. Newton in the solution of the very interesting question he raises I may mention that M. Baillière, Consul-General for France at Honolulu, is in the habit of sending specimens of birds to (I think) the Jardin des Plantes, Paris, where doubtless a specimen might be found. S. LONG.

Hertford, March 15

Unscientific Art

IN the *Graphic* for December 28 there appeared a sketch of a man taking a reading on a marine barometer, on board the *Sarmatian*, during the voyage of the Marquis of Lorne to Canada. To see the scale better by the light of his lantern, the observer is represented as sloping the barometer at an angle of about 30° from the vertical. JOHN W. BUCK

New Kingswood, Bath

ON THE POSSIBILITY OF EXPLAINING THE CONTINUANCE OF LIFE IN THE UNIVERSE CONSISTENT WITH THE TENDENCY TO TEMPERATURE-EQUILIBRIUM

THE idea of the ultimate final cessation of all physical change and life in the universe[1] has been contemplated by many physicists with some dissatisfaction, and with the desire if possible to find some explanation or physical means by which so apparently purposeless an end is averted, and of avoiding the necessity for assuming in past time a violation of physical principles at present recognised to exist.[2] Several attempts have been made to surmount the difficulty,[3] but apparently with no generally satisfactory result. Having given much time to physical problems having a relation more or less to this question, and having always kept the question itself in view, I should like to submit the following conclusion to the readers of NATURE as an attempt to solve the difficulty, though what I have to bring forward is probably not entirely new, as considerations partially tending towards the same final result have already been published by Mr. James Croll, *Phil. Mag.*, May, 1868, "On Geological Time;"[4] and Mr. Johnstone Stoney, "On the Physical Constitution of the Sun and Stars," *Proc.* of the Royal Society, 1868-69. The groundwork of what I have to suggest may be described in a few words.[5]

Taking a general view of the universe, we may consider it as so much matter, which contains a certain quantity of energy. Let us suppose for illustration the energy of

[1] Thomson, "On the Universal Tendency in Nature to the Dissipation of Mechanical Energy," *Phil. Mag.*, October, 1852; Clausius, Ninth Memoir, *Pogg. Ann.*, July, 1865; see also Tait, "Recent Advances in Physical Science," second edition, p. 22.

[2] The allied idea of the whole universe tending to agglomerate into one mass under the action of gravity, the notion of instability thus involved, all this has something incongruous and unnatural about it that appears to be scarcely in harmony with the orderly working of physical phenomena, and would seem to point to the necessity for some additional explanation.

[3] Grove, "Corr. of Physical Forces," p. 67; Rankine, "On the Reconcentration of the Mechanical Energy of the Universe," *Phil. Mag.*, November, 1852, &c., &c.

[4] Also *Quarterly Journal of Science*, July, 1877.

[5] The same problem was considered by the writer in special reference to Le Sage's theory of gravitation in the *Quarterly Journal of Science* for July last, but my present object is to deal with the question entirely independently of any special theories, and solely on the basis of generally accepted facts, or facts which if not known would be in harmony with or deducible from those which are known.

this matter to be raised to such a degree that the whole forms a gas, consisting of separate or dissociated molecules, filling space uniformly. This would evidently be the result of applying sufficient heat, just as for example a gas consisting of compound molecules breaks up into its elementary molecules when sufficient heat is applied, the molecules being unable to aggregate into groups on account of the expansive action of the high temperature. When the temperature of the gas is lowered the molecules (as is known) commence again to aggregate into groups, *i.e.*, to cluster about common centres in chemical union. So in the case of the universe, in the imaginary instance of an (adequately) extremely high temperature, we should have the entire universe consisting of separate molecules or forming a very rarefied gas, the molecules being unable to aggregate into distinct groups under the action of gravity, owing to the enormous velocities of the molecules. The molecules would simply rebound from each other in straight lines, according to the principles of the kinetic theory of gases.[1] Let us suppose, now, the excessive temperature to fall, or in other words the total energy to diminish. Then the molecules would commence to cluster into groups (forming masses) under the action of gravity, the mean size of such aggregated groups of molecules becoming greater as the temperature is less, and the number of such groups diminishing in the same proportion. At first, by a slight fall of temperature we should have a large number of small groups (or clusters) of molecules; by a further fall of temperature a further clustering of molecules under the action of gravity would occur, *i.e.*, the size of the separate masses would increase and their number diminish. The case is, in broad principle, exactly parallel to that of a compound gas when subjected to extreme variations of temperature, indeed as far as the purely mechanical considerations are concerned, it is only a question of scale.[2] We know that when a compound gas whose molecules possess a high complexity has been heated up to the temperature of dissociation, and the temperature is gradually lowered, then at first only a clustering of elementary molecules takes place; but as the temperature is further lowered, these compound molecules may cluster together to form compound molecules of a secondary order or higher degree of complexity (*i.e.*, molecular clusters of a larger mass). Thus the mean mass of the clusters of molecules in the gas increases as the temperature is lowered, and the number of such clusters (or centres of aggregation) diminishes correspondingly.

We will therefore suppose that the universe has attained a final state analogous to this, *i.e.*, such that the mean mass of a cluster of molecules (a stellar mass) and the number of such clusters (stellar masses) is such as exactly to represent that which must exist by the actual mean temperature of the universe. But it may be said, as far as we are able to appreciate and judge of the universe, it certainly appears as if the entire universe were losing its heat in the ether of space, and that this final state of things (equilibrium) were not yet attained. But it may be urged, in reply, we are judging of the entire universe from the point of view of a single stellar sun to which we belong. It is as if we were to judge of the temperature equilibrium of a gas from the point of view of a single molecule (or of a few others surrounding it), in which case it is certain we should be unable to form an idea of the state of temperature equilibrium of the gas. It is known to be a demonstrated consequence of the kinetic theory that the utmost diversity exists among the velocities of the molecules of a gas, or the temperature from molecule to molecule. In order to have a true idea of the state of temperature of the gas, we must investigate the conditions of a region containing some thousands of millions of molecules (any appreciable region of space actually containing this number). So in order to have an adequate idea of the state of temperature equilibrium of the universe, we should require the mean temperature (state of energy) of a region containing some thousands of millions of stellar masses, not the narrow view we have from one of these, and the velocities of the few we have measured—not to speak of the countless dark suns that may exist in space, and about whose velocities we know nothing. Mr. Croll has pointed out[1] how it is probable that such dark suns may possess exceptionally high velocities, as the bright (visible) suns would naturally have lost in the collisions which developed their heat part of their normal velocity of translation, the translatory motion having been partly lost by conversion into heat. In the parallel case of a gas, it is a known fact that even if the mean temperature of the gas be low (less than normal temperature), some molecules in certain parts must acquire in the accidents of collision enormous velocities, and are thrown into very forcible vibration at the encounters, such that they would become luminous if we were able to visualise single molecules. In other words, if *all* the molecules of the gas possessed the velocities of these single molecules (relatively few in number), the entire gas would appear like a flame. So in like manner, though single stars in the universe may be luminous, it (by analogy) by no means follows that this at all approximately represents the mean condition of the entire universe. This luminous state might be quite exceptional, and the mean temperature of the universe might be exceedingly low for aught we may know. We may happen to be in a part where the mean temperature of the component matter is exceptionally high, as, of course, from the fact of our being in existence, we must be in a part which is suited to the conditions of life. What is there, then, to oppose the inference that the mean temperature of the universe may be such that each stellar mass (or detached portion of matter, glowing or not) on an average receives as much heat from others as it emits itself, in analogy to the molecules of a gas in equilibrium of temperature; and this does not prevent single stellar masses (in analogy single molecules of the gas) from acquiring exceedingly high temperatures, indeed, they would naturally acquire this from the encounters in certain instances, according to the accepted principles of the kinetic theory.

As regards the state of aggregation of the matter of the universe as dependent on the energy, it would clearly in the same way be misleading if we were to attempt to judge of the mean state of aggregation from the point of view of the few masses in our immediate neighbourhood (or the narrow range of the universe overlooked by us). Thus, to recur to the smaller scale illustration of a gas. In the case of the molecules of a compound gas in a state of temperature-equilibrium, it is known that some of these compound molecules (representing a cluster of molecules aggregated about a common centre) must acquire now and then, in the accidents of collision, velocities corresponding to dissociation temperature. The compound molecule is thus broken up into its components at the collision, these components clustering together again in some other part of the gas, the *mean* state of aggregation remaining unchanged. Thus it would evidently be misleading to judge of the state of aggregation of the molecules of a compound gas from the point of view of an inappreciable region, containing a few hundred thousand molecules, which might in the accidents of collision have become exceptionally heated. In order to judge of the state of aggregation of the gas, we must investigate that of an appreciable region, containing some thousands of millions of molecules. So in the case of the universe, it

[1] The deflection from a straight line owing to the feeble action of gravity in the case of single molecules, would evidently be inappreciable.

[2] There is, of course, this detail of difference, viz., that while the aggregation of molecules about a centre in chemical action is limited, the aggregation in the case of gravity is unlimited. We merely apply in principle the same general considerations to molecules aggregated into clusters (lumps) under chemical action, as to molecules aggregated into lumps under gravific action (stellar masses).

[1] *Quarterly Journal of Science*, July, 1877.

would obviously be fallacious if we were to form an estimate of the general state of aggregation from that of the few masses we can judge of in our immediate vicinity; but we should require to know the condition of a region of an extent that we have no chance of overlooking, and under the principles of the kinetic theory, the local variations of the states of aggregation (themselves depending on local variations in the velocities of the masses) would fluctuate within wide limits. In order to have an idea of the actual (mean) state of aggregation, a being would be required that could (on comparative scale) sweep over the universe with the same facility as we sweep through or examine regions in a gas representing a multiple countless millions of times that of the mean distance of the detached portions of matter composing the gas.[1]

We are led to apply the principles of the kinetic theory to the case of the universe not so much as a speculation, but rather as a necessary deduction following from the known principle that detached masses moving freely in space (as the stellar masses are observed to do) and at such distances apart that gravity between the several masses is incompetent to deflect the path of the masses appreciably, must move in straight lines, and have their motions regulated under the mutual encounters in accordance with the principles of the kinetic theory. Only in the relatively near approach of the masses to one another does gravity come sensibly into play and deflect the path, causing under certain conditions rotation about a common centre (double stars), or, perhaps, by almost direct impact, nebulæ with but feeble rotation, &c.[2] To carry the analogy again to the smaller scale-case of a gas, it is there known that the molecules are in some cases feebly impelled towards each other at a near approach, the path of the molecule being thus deflected at its termination, whereby the conditions are given for causing a temporary rotation of the pair of molecules about a common centre, in an analogous way. The relatively vast distances of the stellar masses, compared with their dimensions, would involve, as a rule, an extremely long mean path before the encounters, corresponding to a proportionally long epoch of time adapted to the conditions of life. The apparent extreme simplicity of the means to the end by the application of the kinetic theory to the case would at least seem not to be out of harmony with its truth.

Thus the final conclusion to which these considerations lead would be that the universe has attained its final state of temperature equilibrium (if we set no fixed limit to its past existence), in the sense that if we were able to measure the temperature (or contained energy), of a sufficient number of masses through a sufficiently extensive region, we should find that in every such *equal* region throughout the universe the temperature (or contained energy) would be the same; just as (on a smaller scale) in the case of a gas, if we could measure the temperature of some thousands of millions of molecules in a given region, we should find that though the temperature differed to a practically unlimited extent from molecule to molecule, yet the temperature of every such equal region was the same.

[1] Just as in the case of a compound gas, the *uniformity* of temperature, of states of aggregation, &c., does not apply to the individual unit lumps of matter (molecules) forming the gas [which may be in vastly different states from one to the other]—but to unit *volumes* containing vast numbers of such units; so in the case of the universe, the uniformity of temperature, state of aggregation, &c., would not apply to the unit lumps of matter (stellar masses) but to unit volumes. In fact the universe may be regarded as a larger scale gas, with the difference that the central force producing the aggregated lumps of matter that move as wholes is not chemical action but gravific action. If we imagine (merely for illustration) a being on relative scale situated on a single compound molecule of a gas in a state of normal temperature equilibrium; this minute being would observe vast differences of temperature and of states of aggregation around him (some molecules in scattered parts glowing in a state of dissociation, &c.), and he would form a perfectly wrong judgment of the state of the gas from such a narrow point of view. So the observer connected with one unit lump of matter of the universe (stellar mass) can form no idea of the state of the rest from his narrow point of view.

[2] The occasional flashing out of stars, as if due to some sudden convulsion that might be referred to collision as a suitable cause, is a notorious fact in astronomy; though, from the extremely limited view of the universe that we possess, it would be unreasonable to expect such phenomena to be of frequent occurrence.

So in an analogous way as regards the *state of aggregation* of the matter of the universe, since this depends on the temperature, it would follow, assuming an indefinite past time, that the mean state of aggregation of the matter, like the mean temperature (mean energy), is the same throughout, *i.e.*, the average size of the separate masses, or the number in unit of volume (taking sufficiently large units of volume for comparison) would be equal throughout, though indefinite fluctuations of dimensions would occur from one mass to another, in analogy with the fluctuations of velocity from one mass to another.

It would further follow from the known principle that molecules of different densities (molecular weights) tend forcibly to become uniformly diffused, that by an indefinite past duration of the universe all the matter must be uniformly diffused if (as in the case of uniform velocity and uniform state of aggregation) regions of sufficient extent could be taken for relative comparison. This again resembles in principle the smaller scale case of a gaseous mixture, where it is known that the small detached portions of matter (molecules) are uniformly mixed, only when appreciable regions containing vast multitudes of molecules are examined, but that there is room for considerable local fluctuations of mixture (such as if only a few hundred thousand molecules were examined).

Thus it appears that the kinetic theory, applied to the universe, would have the peculiar characteristics of allowing almost indefinite local fluctuations of temperature, of states of aggregation, and of composition, of the matter forming the universe within regions very extensive, absolutely speaking, but infinitesimal, relatively speaking (*i.e.*, in comparison with the boundless universe), these regions being amply extensive enough to allow an amount of activity and variability of energy adapted to the conditions of life; while at the same time the principles of the theory, from their very nature, involve perpetually recurring and yet indefinitely variable changes within certain localised limits, the constitution of the vast whole (looked at broadly) remaining uniform throughout.

S. TOLVER PRESTON

FRITZ MÜLLER ON A FROG HAVING EGGS ON ITS BACK—ON THE ABORTION OF THE HAIRS ON THE LEGS OF CERTAIN CADDIS-FLIES, &c.

SEVERAL of the facts given in the following letter from Fritz Müller, especially those in the third paragraph, appear to me very interesting. Many persons have felt much perplexed about the steps or means by which structures rendered useless under changed conditions of life, at first become reduced, and finally quite disappear. A more striking case of such disappearance has never been published than that here given by Fritz Müller. Several years ago some valuable letters on this subject by Mr. Romanes (together with one by me) were inserted in the columns of NATURE. Since then various facts have often led me to speculate on the existence of some inherent tendency in every part of every organism to be gradually reduced and to disappear, unless in some manner prevented. But beyond this vague speculation I could never clearly see my way. As far, therefore, as I can judge, the explanation suggested by Fritz Müller well deserves the careful consideration of all those who are interested on such points, and may prove of widely extended application. Hardly anyone who has considered such cases as those of the stripes which occasionally appear on the legs and even bodies of horses and apes—or of the development of certain muscles in man which are not proper to him, but are common in the Quadrumana—or again, of some peloric flowers—will doubt that characters lost for an almost endless number of generations, may suddenly reappear. In the case of