tree-ferns have ever been found in English eocenes. In the same way on the evidence of three seeds, which he supposes to be grape stones, and some cactus spines, we read that "the trees of the ancient forest were evidently festooned with vines, beside which the prickly Rotang-palm twined its snake-like form." Indeed, in addition to the error he committed in calling them miocene, all Heer's determinations of the Bovey Tracey plants require revising.

The Alum Bay leaf bed, familiar to geologists for twenty or thirty years, appears at last to have almost given out, for the leaf bearing pipe-clay is washed away to such an extent that a fortnight's stay scarce yielded a dozen of the commoner leaves. The unusual rainfall has also nearly obliterated the Hempstead section, and the face of the hill resembles a glacier of mud, which has carried trees and bushes, in place of rocks, into the sea. A lady, my brother, and myself had the misfortune to select that route home, returning from Gurnet Bay when darkness was coming on. The only passage over the deep and perfectly soft mud streams lay through the dead brushwood which fringed them. The tide was high on one side, and up the escarpment on the other lay mud and brushwood of the most impenetrable character, while with a tide still rising and darkness increasing, it appeared as hopeless to attempt to retrace our steps as to press on.

The following, from my note-book, has even less connection with fossil leaves, but the experience may be of use to geologists visiting the district.

At Alum Bay a large area of weathered chalk, usually supposed inaccessible, can be explored without much danger, for it is almost everywhere possible to descend to the sea-level between the Needles and the beacon on Freshwater Down. The face of the cliffs is traversed by numerous faintly marked tracks, which it is difficult to suppose could ever have been of service except to smugglers, for the shore line is rocky and not used by fishermen. Those who appreciate the bolder coast scenery of our white chalk will be repaid by climbs even of 500 or 600 feet, to the perfect solitude of the water's edge. If accompanied by ladies, a rope will be found a proper precaution and useful in lessening the exertion to them. One of the easiest ways is directly under the beacon, and there is a path down into Scratchells Bay, just inside the railing of the fort, whence at low tide the second of the Needles can be reached.

At Bournemouth we had a rather narrow escape. I foresaw that during this year's digging unusual caution would be necessary, owing to the heavy and saturated state of the cliff. I was obliged, however, to go through some fifteen feet of sand to reach a lower bed from which I expected to get pinnæ of *Goniopteris Bunburyi*. I had dug out a piece of this bed from end to end; a distance of about twenty feet by three or four feet wide; and the cliff above this narrow excavation consisted of some fifteen feet of vertical coarse sand, capped by indurated ironstone, and a thick black clay bed, above which the cliff sloped away at an angle. To expose a little more of the leaf bed we ventured at one point to slightly undermine the verticality of the cliff, before replacing the sand and clay we had dug out. During a pause for lunch sand fell twice upon the leaf bed cleared for work and was shovelled off. On a sudden loose pieces seemed to be falling all along the face of our pit, and with no more warning than an impulse to throw ourselves out of danger, huge boulders of clay and ironstone tore by—which from their weight were afterwards immovable to us—our excavation was completely filled in, and our tools still lie buried under the *débris*. I was helplessly buried for a few minutes up to my shoulders in sand, anticipating another slip, which fell soon after I was extricated.

J. STARKIE GARDNER

RECENT EXPERIMENTS ON RADIATION

EXPERIMENTS on radiation have a twofold interest. Accurate measurements of the increase of radiation due to an increase of temperature have of course a great theoretical value, but in addition to this, there is the practical question of a possible measure of temperature by means of the radiation of a body. It is this practical question with special reference to the temperature of the sun which seems chiefly to induce experimenters to study the subject with improved methods. It has led at any rate Mr. Rossetti to furnish a most valuable contribution to the study of radiation.[1]

Newton was the first to give a formula connecting the quantity of heat radiated by a body with the temperature of the body; but his formula was not sufficiently accurate, and has been replaced by another first given by Dulong and Petit. But Dulong and Petit's formula also breaks down when the difference of temperature between the radiating body and the inclosure is large.

Mr. Rossetti, trying to improve on Dulong and Petit's formula, deduces from his experiments the following for the radiation of lampblack:—

$$y = a\,T^2\,(T - \theta) - b\,(T - \theta),$$

where y is proportional to the thermal effect of the radiation, a and b are constants, and T and θ are the temperatures of the body and the inclosure, as measured on the absolute scale. This formula seems certainly to be as far superior to Dulong and Petit's as this latter was to Newton's. The last term generally is but small compared to the first, and Mr. Rossetti believes it to be due to the effect of the surrounding air, although we do not quite see how this can be. The following experiments prove how accurately the formula may be made to represent the facts. The constants a and b were obtained by measuring the radiation of a Leslie's cube filled with water or mercury, and gradually heated up to 300°. A piece of copper foil covered with lampblack was then heated in a flame of alcohol. The temperature of the flame lies between 390° and 400°; and two numbers obtained by means of the above formula were found to lie between these limits. The radiation of a red hot copper sphere was then determined, and its temperature independently measured by means of a calorimeter. The temperatures obtained by the two methods were 762°·1 and 763°·6 respectively.

In order to find the temperature of the copper sphere account was of course taken of the emissive power of copper as compared with lampblack. For this purpose, Mr. Rossetti has invented an ingenious method to determine this emissive power of various metals at the temperature of the Bunsen flame. That a formula obtained by means of experiments made between 0° and 300° C. should give such accurate results for a temperature of 760° is already a good proof for the usefulness of the formula, but Mr. Rossetti has pushed his verification even further. A cylinder of oxychloride of magnesium was heated in a flame of coal-gas and oxygen. The temperature was found to be about 960°, and in a flame it was found to be 2,167° and 2,397° in two experiments. Platinum melted easily in the flame, and hence the temperature could not have been far wrong.

Before Mr. Rossetti can apply his formula to determine the sun's temperature, he has to determine the absorptive effect of our atmosphere; but we shall not enter here into this part of the question. The sun's *effective temperature* is the temperature he would have, if he had the emissive power of lampblack. Mr. Rossetti finds this effective temperature by his formula to be a little below 10,000° C. Taking account of the fact that the sun himself is surrounded by an absorbing atmosphere, and accepting some data given by Secchi for the amount of this absorption, the temperature of the photosphere is found to be above 20,000° C.

[1] Reale Acc. dei Lincei (3) II. 6 Jan. 1878.

Prof. Langley's observations[1] were chiefly made with the view of shewing that the low estimates of the solar temperature which have recently been made on the basis of Dulong and Petit's formula must be wrong. Prof. Langley compared directly the heat and light received by the sun with that received by the hottest luminous source he could find. He chose the mass of liquid steel obtained in the Bessemer process. The result was that the solar heat radiation was at least eighty-seven times as strong as that of the liquid mass. It is impossible to compare this result directly with the values obtained by Mr. Rossetti; but a rough idea of a fair agreement may be obtained. Mr. Rossetti fround the solar radiation to be about forty times as strong as the radiation of a lampblack body in the hottest oxyhydrogen flame he could obtain. Taking account of the emissive power of iron, we find that the radiation of the molten steel must have been a little more than half that of a black body in the oxyhydrogen flame which is possible. Prof. Langley also compared the intensity of light sent out by his two sources, and naturally found a much larger difference. We do not agree with Prof. Langley's remark that the solar light radiation is a more trustworthy indication of the total difference between the sum of all degrees of radiant energy than the heat. In fact the heat radiation is the only correct indication of the total radiant energy.

Another interesting contribution to the study of radiation was lately made by Mr. Nichols.[2] Mr. Nichols heated a platinum wire to successive degrees of incandescence by an electric current, and compared the intensity of the luminous radiation in different parts of the spectrum with the incandescence of another platinum wire kept at a constant temperature by means of an electric current. There is a great experimental difficulty in determining the temperatures of the wires, and Mr. Nichols had to content himself with measuring simply their increase in length. Matthiessen's formula will give an approximate idea of the real temperature, but it must be left to future measurements to decide how far Matthiessen's formula can be applied to high temperatures. The chief part of Mr. Nichols' work consists therefore in finding the luminous radiation of platinum, not on an absolute scale, but in terms of an incandescent platinum wire of fixed but unknown temperature. In order to reduce his measurements to an absolute scale Mr. Nichols compared the radiation of his standard with the luminous radiation of the sun, and then employed Lamansky's measurements of the heating effects of different parts of the solar spectrum. The solar spectrum is however a bad medium of comparison, owing to its discontinuous character. There is, for instance, such a strong atmospheric absorption near D that the radiation of the region near D is seriously weakened; which weakening is entirely dependent on atmospheric conditions, and therefore makes comparisons taken at different times illusory. Thus the final curves obtained by Mr. Nichols for the absolute radiation of platinum wire at different temperatures show a discontinuity near D which is evidently produced by the above-mentioned cause, especially as Mr. Nichols did not use sunlight, but light reflected from clouds.

Mr. Nichols also tries to deduce from his experiments the fact that platinum a little below its melting point has a much larger absorbing power than at ordinary temperatures. The whole argument rests however on the assumption that the temperature of a platinum wire is the same as that of a lampblack body when the relative intensity of red and blue light given out by the lampblack body is the same as that given out by the platinum wire. That is to say, Mr. Nichols assumes that the emissive power of platinum is the same for rays of all refrangibilities. But it is evident from Mr. Nichols' own measurements that the temperature of a petroleum flame (used by Mr. Nichols) determined in this way is found much too high. It does not require a large correction in this temperature to bring the value of reflective power of platinum at the temperature and by Mr. Nichols to the same value as that found by Provostaye and Dessains for ordinary temperatures. In the memoir of Mr. Rossetti, an idea of which we have tried to give above, this reflecting power of platinum is directly measured at a temperature of the Bunsen flame, and was found to be strikingly in accordance with the number given by Provostaye and Dessains.

ARTHUR SCHUSTER

[1] Proceedings of the American Academy.

[2] "Ueber das von glühendem Platin ausgestrahlte Licht," E. L. Nichols. Göttingen: E. A. Huth.)

NOTE ON A CONSOLIDATED BEACH IN CEYLON

A SOMEWHAT interesting consolidated beach exists on the west coast of Ceylon, a few miles to the north of Colombo. The writer had only one opportunity of visiting and examining for a short time this formation: but there are certain features in connection with it that cannot fail to be of interest, however short the examination may be. The beach extends continuously in almost a straight line for about four or five miles, and is manifestly in process of formation at the present time, as some portions of it are so soft that they can be easily crumbled in pieces by the hand, whilst others are much harder than gneiss, and can only with the greatest difficulty be fractured by means of a heavy hammer. Between these extremes are all gradations of hardness, and the ordinary shells of the coast may be found in almost every part of the beach more or less firmly embedded in the rock. The highest part of the formation is just within reach of the waves at high tide; but it is difficult to ascertain with any degree of accuracy how far it extends into the sea, on account of the difference between high and low tide being only about two feet. The beach is seen at a glance to be composed chiefly of a faint brownish-coloured rock, with frequent strata of black material of very varied thickness and irregular shape. An examination of specimens shows that the brown rock is composed almost entirely of quartz fragments, and that it possesses only a low specific gravity (2·91), whilst the darker portions are extremely heavy as well as extremely hard. Several specimens gave a specific gravity of 3·9, 3·93, 3·94, the dried sand, freed from its carbonate of lime by means of dilute hydrochloric acid, possessing a specific gravity of 4·32. A microscopic examination of this sand and also of sections of the rock showed that the chief constituent, and that which gave it its dark appearance, was magnetite, corundum in various forms being also present, with here and there a fragment of quartz. One noticeable point was that the fragments of the harder constituents were in nearly every case hardworn, and rounded, whilst the quartz showed traces of recent fracture in the shape of sharp edges and angles. The size of these fragments varies very considerably, those of magnetite ranging from ·005 inch to ·02 inch, whilst those of quartz are much larger, frequently reaching ·04 inch. The corundum fragments are intermediate in size and rounded in form. It must be remembered that these specimens were taken from only one part of the formation, near the centre of its length and about the limit of high tide. In other positions the fragments will, no doubt, vary very much, the size depending in a great measure on the power of the current to carry them along the coast and up the beach. It was a matter of regret to the writer that he was not able to inspect carefully both extremities of the reef, and examine fragments from many different portions of it. The cementing material of the beach is carbonate of lime, no doubt from the coral reefs along the coast, as there is no limestone rock in the neighbourhood or along the course of the Kelani River, which debouches to the south of the reef. It is not known whence the magnetite and corundum have been derived, except that they have