this we find some pertinent and useful hints on the best mode of grouping hardy perennials, and the art of managing the rock-garden, the wild-garden, water, and boggy ground; on the culture and propagation of early flowers, and other subjects dear to the dweller in the country. Compared with the art of gardening as practised twenty years ago, we are certainly now in an altogether new and improved epoch, and Mr. Robinson is one of the pioneers to whom we are mainly indebted for the introduction of a better and more rational style. A. W. B.

Hints on Shore-Shooting: with a chapter on skinning and preserving Birds. By James Edmund Harting, F.L.S., &c. (London: Van Voorst, 1871.)

A GOOD sportsman, whether he knows it or not, must be more or less of a good naturalist, and this Mr. Harting is. His unpretending little book, therefore, certainly deserves mention here, and the more so since he has worthily won his spurs by making the group of birds most sought by the "shore-shooter" an especial subject of study. What he tells us is the result of his own observation, and is pleasantly told. What he does not tell us is whether "shore-shooting" has, with most people,—for we except him—any other *raison d'être* than the "fine-day-let's-go-and-kill-something" impulse. If not, we really do not see that there is much difference in principle between Pagham and Hurlingham.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. No notice is taken of anonymous communications.*]

An Universal Atmosphere

I HAVE much pleasure in replying to Mr. Browning's question in NATURE, vol. iv. p. 487, as it is one that legitimately strikes at the root of all my speculations, and which, if unanswerable, conveys an objection that must demolish the whole structure I have endeavoured to erect in my essay on the "Fuel of the Sun."

If I am right, the atmospheres of the sun, the moon, the planets, or of any other cosmical body of known mass and dimensions, may be calculated in units of the earth's total atmosphere by the simple formula reasoned out in Chap. iii. of the above-named work, *i.e.*, by multiplying the mass of the body (expressed in units of the earth's mass) by its own square root, thus

$$x = m \sqrt{m};$$

where x is the atmosphere of the body in question expressed in units of the earth's known total atmosphere, and m is the mass of the body expressed in units of the earth's mass.

The mass of the moon being $\frac{1}{80}$ that of the earth, we get $\frac{1}{80}\sqrt{\frac{1}{80}} = \frac{1}{715{\cdot}5416}$, or, discarding fractions, the moon's atmosphere as $\frac{1}{715}$ that of the earth. But the diameter of the moon being to that of the earth as 0·264 to unity, the lunar surface will be to that of the earth as $0{\cdot}264^2$ or 0·0697 to 1, and the lunar atmosphere will be concentrated accordingly, bringing the mean atmospheric pressure on the lunar surface to

$$\frac{\frac{1}{715}}{0\,0697} = \frac{1}{49{\cdot}8355}, \text{ or } \frac{1}{50},$$

nearly of that of the earth's mean atmospheric pressure. Such an atmosphere would support a column of mercury six-tenths of an inch in height. Mr. Browning will recognise this as about equal to the best vacuum obtainable in an old-fashioned air-pump of average defectiveness.

Such is the theoretical pressure upon every part of the moon's surface, supposing the form of the moon to be a perfect spheroid of rotation with a perfectly smooth surface. But the moon is no such regular body. It presents far more irregularities in proportion to its size than would our earth if the ocean were evaporated, and its depths laid bare so that our mountain heights should be measured from the ocean bottom. Under such conditions the bulk of even our atmosphere would occupy the ocean valleys, and very rare indeed would be the remainder that reached the mountain tops and elevated ridges of the earth. On the moon with its filmy atmosphere of only six-tenths of an inch mean pressure, the rarefaction on the high lands and mountains would be carried beyond the limits of observable refractive power under the conditions assumed—viz., of a special atmosphere merging gradually into the universal interstellar medium.

The visible edge of the moon which effects the occultation of a star must in almost every possible case be formed by the ridges and summits of the lunar mountains, in no case by the bottom of the lower valleys, for in looking horizontally across the moon's rotundity these valleys and even the maria must be foreshortened, and their lower depths walled out of the reach of our vision by the great lunar elevations. Thus the occultation of a star would occur without its previous plunging behind any outlying lunar atmospheric matter of appreciable density. We must not forget that Sir J. Herschel's calculation, which assigns one second of refraction to an atmosphere equal to $\frac{1}{1980}$ of the density of the earth, is based on the theory of a limited atmosphere with a sharp and definite boundary suddenly terminating in a vacuum.

But this rarefaction on the elevated portions of the moon demands a compensating condensation or concentration of atmospheric matter in the valleys, crater-pits, and maria. Here the pressure on the moon's surface should considerably exceed the calculated mean. This consideration suggests a very interesting question. Would such an atmosphere, say capable of supporting one inch of mercury, produce any observable effects? If I am right in regarding water as one of the constituents of the universal atmosphere, there are good reasons for supposing that it would.

The small share of water due to the moon would all be raised far above its low boiling point, early in the lunar day, by the heated lunar surface. There would be no sea, no clouds, no rain, no snow, but on the plains and in the valleys a formation of hoar-frost should occur at the lunar eventide, beginning just where the sun's rays become too oblique to maintain the temperature of the rapidly radiating lunar surface above the freezing-point.

In a note appended to Mr. Lockyer's translation of M. Guillemin's work on "The Heavens," the Rev. T. W. Webb thus corrects the author's rather positive statements concerning the total absence of a lunar atmosphere: "After all fair deductions on the score of imperfection of observation or precipitancy of inference, there are still residuary phenomena, such as, for instance, the extraordinary profusion of brilliant points which on rare occasions diversify the Mare Crisium, so difficult of interpretation, that we may judge it wisest to avoid too positive an opinion." Now the Mare Crisium is a great depression of the lunar surface close upon that edge of the moon which, to our vision, first receives and loses the solar illumination. If I am right, aqueous vapour should be suddenly forming there during the early crescent period after the new moon, and the hoar-frost should be as suddenly precipitated as this wide depression rolls towards the darkness after the full moon. In that chapter of the "Fuel of the Sun" which is devoted to the meteorology of the moon and Mercury, I have discussed some of the theoretical results of these conditions and the appearances they should present. I may here merely add that, as the temperature of any part of the moon's unmantled surface must directly and very rapidly vary with the incidence of solar radiation, all the undulating regions of the moon must at morning and evening have a very patchy temperature, the slopes towards the sun being hotter than our tropics, while the opposite side of the same hill receiving the solar rays with great obliquity, and radiating into space almost without impediment, must retain a freezing temperature, and thus the cryophorous phenomena, which Sir John Herschel describes as a possible result of the contrasted temperatures of the opposite sides of the moon, should be effected even by the shady lunar craters and contrasted hill-slopes.

On the highlands of the moon no appreciable amount of hoar-frost precipitation should take place on account of the absence of sufficient atmosphere; but on the deeper maria, wherever the conditions are the most favourable, the patchy temperature should produce patches of such precipitation. If anywhere visible, these should be seen on the Mare Crisium, on account of its proximity to the edge of the moon, for there the morning rays that strike most obliquely upon the cold slopes would be the most effectively reflected towards the earth. Not