

not "partners," for the latter does not participate in the gain of the former. How, then, on symbiotic principles, can "natural selection" have been the means of producing a growth which, though important, if not necessary, to the animal symbiont, is more or less prejudicial to the symbiotic vegetable organism?

There can, of course, be no doubt, as Mr. McLachlan says, that the various peculiarities of gall-structure "could be" explained "on purely physiological grounds if carefully studied;" but that "natural selection" will suffice to explain them, seems to me by no means equally free from uncertainty.

ST. GEORGE MIVART.

Hurstcote, Chilworth, December 13.

The Permanence of Continents and Oceans.

I CAN find no flaw in the reasoning on the dynamical question of the permanence of continents and oceans, in Mr. Starkie Gardner's letter in NATURE of December 5 (p. 103), by which he endeavours to show the universal "tendency for deep oceans to become deeper, and for mountain chains to grow into higher peaks." But when he says it is opposed to no known facts, I wish to ask how it is to be reconciled with the fact of the general distribution of marine deposits over the face of the earth, so that every part of what is now land appears to have once been ocean?

I fully concede that the change of ocean spaces into land spaces is an extremely slow process, taking, probably, millions of years, but it seems to me that it must have occurred, though I cannot suggest through what agency.

Belfast, December 14. JOSEPH JOHN MURPHY.

Does the Bulk of Ocean Water Increase?

MR. JUKES-BROWNE (NATURE, December 12, p. 130) admits that "if the area of the land were larger, and the depth of the oceans less," in early geological times, a further inference must be drawn—"that the bulk of the ocean water was less than it is now."

So far we are in agreement; indeed, we could scarcely be otherwise, as the proposition admits of complete demonstration. When, however, Mr. Jukes-Browne proceeds to give his reasons for holding that the bulk of ocean water *was* less in early times than now, he enters upon a more controversial subject.

I am familiar with the arguments he urges partly on the authority of Mr. Fisher, and have to some extent discussed them in chapter xii. of the "Origin of Mountain Ranges." I desire, however, to point out a further objection that when stated will, I think, appear extremely obvious.

According to Dr. George Darwin and many other astronomers who follow him, our satellite, the moon, was once an integral portion of the earth, having been thrown off when the earth was in a molten condition. If this theory be correct, it is a fair assumption that the magma out of which the moon has consolidated was composed of matter similar to that of our earth. Even if their relations were never so intimate as this, I think most physicists and astronomers will admit a similarity of material constitution of the two spheres.

If then volcanic action on the earth is, as Mr. Jukes-Browne contends, accompanied by a separation of water initially contained in the magma, and its condensation on the surface in such quantities as to materially increase the bulk of ocean water, why has not the same effect followed volcanic action on the moon? Why, in fact, do we not see oceans on the surface of the moon instead of a dry and desert waste of volcanic rings, mountain protuberances, and arid plains? In face of this great fact it appears to me that ingenious arguments as to the amount of water contained in the fluidal cavities of granite, which most geologists think is explicable by percolation, have not much weight.

At all events, it seems a reasonable question to ask why oceans should be supplied with water from the perspiring pores of mother earth, while her offspring, the moon, is so dry as to have absorbed into herself all evidence of any aqueous envelope that may have formerly existed.

T. MELLARD READE.

Park Corner, Blundellsands, December 14.

A Natural Evidence of High Thermal Conductivity in Flints.

A RATHER curious effect of the recent frost attracted my attention in the gravel foot-paths leading over Addington Hill,

near Croydon, on the beautifully bright day of the 1st inst. The clear nights and frosty air of the closing week of last month had been productive of continued low temperatures in that locality, and the result observed was that the flint pebbles, which in neighbouring gravel-beds and here and there on the paths, are of the size of hens' eggs, and remarkably well rounded, had, in places, sunk in the frozen clunch or clay-earth of the foot-paths, and in the peaty ground or turf beside the paths, as it appeared, like filberts shrunk and resting at the bottoms of their shells; or else as if the pebbles' earthy moulds had, by expanding upwards, left such a large vacuity above each stone, that the tops of some of the large ones, instead of being level (as at first they must have been, by the appearance of the moulds) with the surface of the ground, were now, in a somewhat turfy place, about as much as half an inch below it. The physical enigma which hereupon offered itself for elucidation was, how the pebbles could remain at the much lower level, while such a considerable expansion upwards had been brought about by freezing in the moist earth immediately surrounding them; and this problem had certainly, in looking at the thickly-clustered cavities in the frozen ground, at first a very paradoxical appearance.

But if the question how the inclosing cavities of moist earth round flint pebbles which are nearly embedded in it, are disended upwards so curiously by a strong frost's predominance, has presented, it may be, to some of your readers who may have noticed in similar conditions a similar appearance, as it at first did to me, a subject for rather puzzled contemplation and conjectures, it will be worth pointing out, perhaps, that there is a well-ascertained thermal property of siliceous rocks and flint, of which it seems not improbable that this not unfrequently occurring action of a strong frost, in such conditions, may really be an interesting illustration.

Among a series of about a hundred different descriptions and varieties of commonly occurring rocks whose thermal conductivities were experimentally determined by a Committee of the British Association in the years 1874-78, it was found that such entirely siliceous ones as quartz, flint, and pure siliceous sandstone, &c., so much surpass all other ordinary rocks in their rates of transmitting both heat and temperature, that in flint pebbles these conducting powers are, for example, about four or five times as great as in damp sandy mould, or in wet clayey earth.

Instead of the layers of cold temperature, therefore, produced in wet pebbly ground by continued frosty winds and radiation, proceeding in plane levels downwards from one depth below the surface to another, large flints exposed in it must grow cold very quickly through their whole substance, and must freeze the wet earth under them almost as soon as the soil's surface-layer round them is beginning to be frozen. The effect of this freezing process's expansion, it seems evident, will hardly be so much to raise the pebbles and the earth's exposed surface upwards very differently from each other, by the frost's nearly equal action on them both, as, during the frost's continuance, to force up towards the surface a large superfluity of soft earth from between the bedded stones, carrying the cast or mould of the stone's upper sides, itself to some height above them. We would require, perhaps, as an aid to this interpretation of the process, to regard the congelation round the stones, as rooting them down, perhaps to lower-lying ones, so that the upward thrust of the extruded earth may not be able to dislodge them, but can be effective to raise up their frozen caps; but some such supposition as this does not appear to be a very impossible conjecture. By this recourse to the pre-eminent thermal conductivity of flints above that of moist turf and clay, in which they are embedded, it seems at least not impracticable to give a somewhat intelligible explanation of the frozen ground's abnormal elevation round them, lifting the moulded caps of earth-covering off their upper sides until their roadside clusters present the curious appearance of shrunken petrifications of some nest of fossil yolks in half-empty egg-shells.

It is, indeed, true that when by long continuance of a frost the sodden earth may have become entirely penetrated and frozen by it to some considerable and tolerably even depth (we may suppose) below a layer of embedded flints, it should be noticed, to simplify the process's consideration, that the form which the frozen ground will then have acquired between and round the flints could be nowise affected in the end by any various shapes, plane or contorted by irregularly formed and differently conducting solid bodies in its course, wherewith the tract of