LETTERS TO THE EDITOR.

The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.*]

The Habitability of Mars.

INASMUCH as Dr. Wallace has sent me his book through his publishers, as I gather from the wrapper—though it is not so expressed—I suppose it is incumbent on me to acknowledge it, since he clearly expects some sort of reply. The effect of its perusal is to show me again how cogent is the argument for the habitability of Mars, for only by many misstatements of fact, wholly unintentional, of course, can Dr. Wallace make out even a seeming case upon the other side. A physicist will not need to have these errors pointed out to him, but as most readers are unable to correct them for themselves it may be wise to instance a few to show how his house of cards tumbles down in consequence.

On p. 22 he quotes from Miss Clerke to prove that the cap could only supply 2 inches of water over the irrigated districts. Let us assume her own estimate of snow deposited, and merely correct her mathematical and topographic mistakes. She states the maximum area which the cap covers to be 2,400,000 square miles. Now the south cap comes down to 36°·5 latitude on the average, and an easy calculation shows this to occupy 11,330,000 square miles, or to be more than four times as great. Next, she supposes the natural dark areas of the planet to be irrigated, which they are not, mistaking them for the canal system, which, instead of 17,000,000 square miles, covers, oases and all, only about 4,750,000 according to our measures, remembering that the whole of it is not watered from one cap. By combining these two corrections we find, not 2 inches of water for each bit of ground, but 2½ feet, and this according to her own estimate, which there is no reason to suppose not to be two or three times too small. So that it is the argument of Dr. Wallace, and not the cap, that fails to hold water.

An equally fatal flaw affects Dr. Wallace's argument for temperature. Here he bases his deduction on a misstatement of Prof. Poynting. Prof. Poynting states that in my paper on the mean temperature of Mars I took no due account of the blanketing effect of air. Not only did I expressly take it into account, but I did so in the only way it can correctly be taken, not by hypothesis, but by direct appeal to what takes place on earth under a clear and under a cloudy sky by night; and I am glad to know that in a paper he has sent to the *Phil. Mag.* on the subject Prof. Very, the bolometric authority on matters of temperature to-day, agrees with both my method and my conclusion for Mars, and points out where Prof. Poynting's calculations are fallacious.

Another omission is no less telling. Dr. Wallace apparently is unaware that Prof. Very's bolometric determination of the moon's heat, which for delicacy surpasses any previous ones, makes the temperature on the moon during the lunar day reach 356° F. above Fahrenheit zero.

Many more such misunderstandings might be mentioned occurring throughout the book, such as where, from not giving its context, he makes me appear to say that water-vapour is one of the heavier gases, which, of course, I did not.

Again, his theory, taken from Chamberlin, that the interior of Mars can have completely lost its heat in the very process of contraction, and yet later have suffered a meteoric bombardment sufficient to give it a heated outer layer, is mechanically whimsical, not to say impossible. For it can be shown that Mars could not have captured any meteoric swarms not substantially travelling in its own orbit when it coalesced into a planetary mass, and any meteors subsequently encountered could only have fallen on it as it passed through a swarm, yielding a relatively insignificant amount of matter. Any such effect would be even more pronounced on the earth, of the occurrence of which there is no evidence.

Misstatements cannot be too carefully avoided in science, especially when a man, however eminent in one branch, is wandering into another not his own. Dr. Wallace, whose intentions are of the highest, will appreciate this. Indeed, if criticism were confined, as common-sense counsels, to those versed in the phenomena, we should hear very little about the inhabitability of Mars.

Boston, March 6. PERCIVAL LOWELL.

DR. J. W. EVANS'S letter in NATURE of February 27 seems to invite notice from me in respect to three of the subjects with which it deals.

(1) As regards temperature. In most physical problems temperature may be regarded as a single definite measurement, which I understand to be Dr. Evans's point of view; but this ceases to be legitimate in molecular physics whenever the behaviour of an individual molecule comes under consideration. Temperature has then to be recognised as not one, but many, measurements, chiefly of two groups of activities, one group associated with the events that go on *within* the molecule and are in touch with the activities of the æther, and the other group mainly concerned with the journeys of the molecule through space and with one section of the events that occur during each of the encounters to which it may have to submit. Dr. Evans will find this subject referred to, and partly dealt with, at p. 76 of the *Astrophysical Journal* for July, 1904, or in the *Phil. Mag.* of the preceding month. On the other hand, in molar physics (as also in the kinetic theory of gas as usually treated) we have no occasion to deal with individuals; we are only concerned with swarms of molecules acting on one another and changing their behaviour so frequently that the activities of or within the molecules come into operation in too rapid succession to be distinguishable. All that we can then detect is that these numberless activities furnish an average outcome of energy which fortunately is (except in certain critical instances) sufficiently steady to admit of measurement, and is then what we call the temperature. But this jumbling together of unlike activities is not admissible when the question is about individual molecules—as when our object is to learn the conditions under which the lightest gaseous molecules of an atmosphere, which are those most violently tossed about, can occasionally and *one by one* drift away from their atmosphere.

(2) The question whether we can know that Mars is unable to prevent the escape of water is in effect almost the same question as whether we may trust the evidence that helium is in process of escaping from the earth, inasmuch as the dynamical conditions in these two problems are nearly identical. The evidence in the case of helium, so far as it was known eight years ago, Dr. Evans will find on pp. 369, &c., of the *Astrophysical Journal* for June, 1900. It should be added that the discoveries since that date about helium have materially strengthened the evidence then available.

(3) Dr. Evans bases an argument on the early state of the earth, which he thinks could not have been followed by the presence of water in modern times if some molecules can now escape from a planet in the way I have supposed. This, I believe, is a mistake. In the remote past the potential of attraction of the dilated earth of those days may have been, as supposed by Dr. Evans, so much less than now that multitudes of molecules now on the earth were not then upon it. So much may be conceded. But then, as now, these molecules were under the influence of the sun's attraction, and did not range beyond a ring round the sun, in which the earth also travelled—like the rings of Saturn or the asteroids of the solar system. Afterwards, when the earth shrank and the potential of its attraction rose to near its present amount, such of these molecules as encountered the earth were unable to escape again and we now find them upon the earth. There is therefore no such conflict as Dr. Evans supposed between this possible past and the argument I have based upon observed facts, viz. upon the absence of all the gases of its atmosphere from the moon, and on the escape from the earth of molecules of hydrogen and helium which is still going on.

The more deductive method of investigating the escape of gases from atmospheres, without the premisses from