

So far as I know, there does not now remain a single mathematician or astronomer who favours a purely astronomical theory of an Ice Age; a theory which, as Arago, Humboldt and Croll, all urged long ago, is quite inadequate to explain the climatic effects required. Every one, as far as I know, now agrees with the American astronomer Meech, who subjected the astronomical theory to a most searching analysis, as far back as 1857, that "the causes of notable geological changes must be other than the relative position of the sun and earth under their present laws of motion." It is with this sentence that I close my own analysis of the problem in chapter ix. of my "Glacial Nightmare."

As I understand, Sir R. Ball in surrendering his old view, which was that astronomical causes by themselves are sufficient to produce an Ice Age, falls back upon a modification of Croll's meteorological argument. While, however, he no longer relies on the adequacy of astronomical causes alone as competent to produce an Ice Age, he does not admit the conclusiveness of Mr. Culverwell's argument, but bids us remember that the world cannot be cut up into a number of parallel zones shut off from each other by solid partitions, each one of which can be treated as a separate climatic region, but that the climate of every zone is very largely indeed the result of heat brought in or carried away by air and water from or to other zones. No one disputes this. It is in fact an elementary postulate of meteorology, and applies as much to Sir R. Ball's arbitrary zone termed a hemisphere as to any other.

What we want Sir R. Ball to do is not to rest content with this barren postulate, but to apply it as Croll applied his postulates, and to prove that, granting the greatest possible alteration of the relative length of the seasons due to eccentricity, &c., which, as Mr. Culverwell has shown, will by itself tend to shift the climate of each zone about five degrees, how is this going to affect the circulation of the air and of ocean currents sufficiently to constitute an Ice Age? This was the problem Croll virtually set himself to analyse by a minute and ingenious investigation.

Croll's arguments have been riddled through and through by several writers, and in this behalf I may perhaps venture to again refer to a minute dissection of them in a chapter, headed "Transcendental Meteorology," in the work already cited, namely, the "Glacial Nightmare," and which I have been told by some eminent physicists is unanswerable. I can, at all events, say it has not been answered.

If Dr. Ball can discover some method of curing the radical defects of Croll's arguments, he will have made us a valuable present. Meanwhile, if I do not entirely misunderstand his present position, it is more clear than ever that he owes it to us all to withdraw his "Cause of an Ice Age" from circulation, for it has not only been condemned by its distinguished and formerly friendly critic, but has been actually condemned by its own author.

HENRY H. HOWORTH.

Athenæum Club, January 30.

The Positions of Retinal Images.

PROF. KULPE, in his "Outlines of Psychology" (translation by Prof. Titchener), sets out with much effectiveness the argument in favour of believing that the visual perception of extended surface is an original datum of consciousness attached to the extended retinal surface (and no more to be explained than why the sensation red feels the way it does, and not otherwise); and he also shows conclusively that the peculiarity of nerve-excitation by which right- and left-ness and up- and down-ness are distinguished, is of peripheral (and not of central) origin; by adducing the facts of metamorphopsia, that is, the cases in which a portion of the retina has become detached by a wound, and has afterwards grown on again, and in which vision is correspondingly inverted—exactly as when a piece of the skin of the forehead has been grafted upon the nose, say, and upon touching it we seem, for a long time afterwards, to be touching the forehead. He thus attaches himself to the innate-space-sensation theory of James and Sumpf. But his effort to show that the out- and in-sensation is fundamentally dependent upon the different shape of the image cast upon the two retinas by an object, carries less conviction with it. This is, of course, an essential element of the sensation when the object looked at is so complex as to consist of two points at a given distance from each other. But when it consists of a single bright point only, we are still perfectly able to determine its position in depth (if it is looked at with two eyes), and the sensation-element which enables us to do this is plainly more fundamental than the other.

To say the least, it is something which ought not to be overlooked.

It is plain that in this case the only criterion which is left us (granting, what is the case, that the localisation can be effected with certainty with two eyes, but only vaguely and indefinitely with one) is the distance apart of the double images; it is that which we estimate, unconsciously of course, in spite of the fact that one image is in one eye and the other in the other, and it is that which we translate, without difficulty, into a feeling of depth. But there is always an ambiguity; for every point, O (Fig. 1), without the horopter-circle, which casts images upon the retina at the points r and l , there is a congruent point, O', within the horopter-circle, which casts images upon the corresponding retinal points, l' and r' , and which, therefore, gives images which are at the same distance apart. We have no difficulty in sensation in distinguishing between a bright point at O and one at O', but how can this be effected? There is still a difference in sensation between the two cases. The nasal half of each retina gives distinctly brighter images than the temporal half; in the case of the object O, which gives the two images, r and l , the remoter one is the brighter, while in the case of the object O', which gives the images l' and r' , it is the nearer one which is the brighter. A bright image of the object, which seems to us to be the thing itself, is attended by a somewhat fainter secondary self, whose presence we are absolutely unconscious of, in our non-scientific lives, as an image,¹ but which we evaluate with the utmost nicety as a sign of the distance away of the real object,

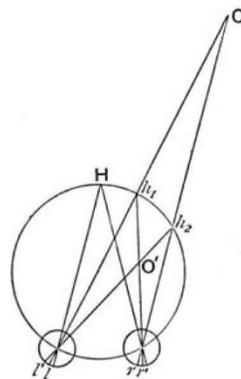


FIG. 1.

and which has, moreover, a different significance according as it stands nearer to, or further from, the fixation point than the image which we regard as the object itself. This explanation may seem at first to vary much in the air, but its correctness has been demonstrated by Schön in a very ingenious manner (*Arch. f. Ophthalm.*, xxii. and xxiv.). His experiment has been unaccountably overlooked by all the makers of text-books, as far as I have seen, but it is of critical importance. He arranges a series of screens with openings in them in such a way that two different bright objects are seen, one by the right eye only, in the line h_2O produced, and the other by the left eye only, the line h_1O produced. The positions of the double images now correspond equally well for an object at O or at O'; and the person experimented upon thinks he sees an object now at O and now at O', exactly in accordance with the way in which the relative brightness of the objects beyond the screens is made to vary. When the image which falls at r is brighter than that which falls at l , the object is seen at O; when the image which falls at l is brighter than that which falls at r (sufficiently brighter, of course, to counteract the relative efficiency of the different halves of the retina) the object is seen at O'. It is therefore demonstrated that it is the relative brightness of the images which is the determining factor in enabling us to localise objects in one or other of the two congruent worlds without and within the horopter-circle. I have myself repeated the experiment with perfect success.

C. LADD FRANKLIN.

Baltimore, January 13.

¹ There are many people who cannot bring the secondary image into consciousness, no matter how hard they try, when it falls at any distance from the fovea.