eras not notably different from that of to-day. The facts even justify the seemingly extravagant statement that at several stages in geological history, early and late, the surface of the ancient ocean did not vary a foot from that of the present, since it must have passed both above and below the present horizon repeatedly during the earth's history. Geological evidence, therefore, interpreted on its own legitimate basis, seems to lend no appreciable support to any theory that postulates a high speed of rotation for the early earth, or a low speed of rotation for the present earth, unless that hypothesis is correlated with the assumption of an almost perfect adjustability of the form of the earth to the changing rotation, in which case the argument of Lord Kelvin set forth on p. 670 stands confessedly for naught.

If we postulate a slow accretion of the earth and of the moon alike, the whole subject of the former speed of rotation of the earth and the relations of the earth to the moon take on a new aspect and invite investigation along the lines of new working hypotheses. Can it be shown that it is absolutely necessary that the aggregating meteoroids gave to the earth an exceedingly high rotation at the outset? Is not this assumption of high rotation merely an offspring of the nebular hypothesis? If the moon were aggregated slowly and came into tidal functions at a late stage, and at a distance from the earth's center quite unknown, may not all its relations to the earth have developed on much more conservative lines than those worked out by Darwin and at the same time preserve those apparently significant relations to the movements of the two bodies to which Darwin has so strongly appealed in support of his hypothesis of the history of the two bodies? In other words, without challenging the validity of Darwin's most beautiful investigation in the essentials of its method, may not a change in the premises deducible from an equally legitimate hypothesis of the original condition of the two bodies lead to results in equally satisfactory accord with the existing relations of the two bodies?

At any rate, as remarked at the outset, the time-limits assigned on tidal grounds are not very restrictive, even on the assumptions made, and when they shall be worked out on revised data in accord with the newer hypotheses they may, perhaps, even be found to favor the longevity of the earth and become one of the arguments in support of it.

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(To be concluded.)

PERSPECTIVE ILLUSIONS FROM THE USE OF MYOPIC GLASSES.

THE phenomena to be described occurred during the first days' use of myopic glasses, and may be grouped under the following heads:

a. There was an apparent diminution in size of moving objects—persons, animals, street cars—as compared with buildings, natural scenery, and, in general, with the elements of the background of the visual field. Here the total visual fields of the normal and of the myopic eye are equally extensive; there are the same number of projection points in each. Over this background, in the case of a myopic individual, there is distributed a relatively small number of distinct and at the same time interesting or important objects. When the near-sighted person puts on powerful glasses the number of such important and interesting distinct objects thrown upon this background is vastly increased; it is crowded with a multitude of persons, animals, trees, buildings, and the like. There are here two sets of factors whose interpretation in terms of perspective point in divergent directions. Multiplicity of objects in the visual field

means farness of the observer from the things viewed, while definiteness of detail in the individual object means nearness in point of view. In the given case there is, relatively to the number of discernible objects, an abnormal distinctness, or, relatively to their definition, an abnormally great number of objects. Adoption of the one as criterion will lead to an underestimation of size; adoption of the other will result in an overestimation of distance. The former actually obtains, and for this reason as it appears.

The dominant factor of the change in character of visual objects here is the increased distinctness of them at any given distance—the greater definiteness of line and shadow, the elaboration of detail. Such distinctness of form means in general nearness of the object to the observer. Now the near object in order to be seen as a total, a unity, must be comparatively small. The arrangement of a garden plot cannot be grasped while one walks along its paths as when viewed from a window overlooking it; the course of a river can be apprehended only when seen from some neighboring height. The same holds true of smaller as of larger groups of elements—the observer must step back in order to get the general effect—*i. e.*, to appreciate the factors as a total object. The more complex or grander the proportions of an object the farther away must be the point of view from which it can be grasped as a unity. If, then, it is so to be apprehended while yet near to the observer its parts must be small and simple. In the case in question the effect of the new glasses was thus to increase the definiteness of detail in visual objects, while these objects were still regarded as totals, a combination directly tending to produce that sense of smallness in the individual object which was actually noticed.

Another fact points in the same direction. Of curved surfaces a large radial extent can be seen distinctly by the myopic eye only when the object is a small one, and, therefore, not greatly affected by the parallactic angle. Of equally distinct objects, therefore (which in the two cases will be at different distances), the myopic subject sees less curative-extent than the normal; or, for two equally distinct objects in the myopic field of view (which are, therefore, at the same distance from the eye) greater visible extent of curvature means smallness of size. By the use of the new glasses the extent of visible curvature was thus increased, while the distinctness of the objects' details remained unaffected. This influence, therefore, coöperated with the preceding to produce the feeling of unnatural smallness in the nearer objects of vision.

b. The change in relative curvature-extent visible from the point of distinct vision appears to have been active in the production of another perspective illusion, the exaggeration of curvature in objects bounded by convex surfaces. The cheek or brow of a person, for example, appeared to bulge out unduly in the middle, and there was a constant tendency to put out the hand and test by touch the accuracy of of the sight perception. In the myopic eye the point of view of distinct vision lies so near to its object that for any given group of things the perceived curvature extent is small in comparison with that visible to the normal eye. In objects beyond the range of distinct vision, when such are not overlooked and referred to the unnoticed background, the curvature gradations are obscured and the myopic eye must depend upon other cues for its interpretation of convexity degree. It reinforces the perception by contributed curvature elements. When the finer gradations of curvature are restored to sight by the stronger glasses the contributed emphasis appears to be continued, with the result of an apparent exaggeration of curvature. I have not had

opportunity to observe if in the case of concave surfaces there is an analogous exaggeration of hollowness or depth.

c. The use of stronger glasses produced an apparent dimunition in the perspective relations of objects within the visual field, which at times reached almost the vanishing point. Men and women on the street were silhouetted against the background of trees and houses, or moved like shadows over a screen. A similar reduction in perspective can be produced by piercing a bit of cardboard with a small hole, and viewing a group of objects in the middle distance through it, while the cardboard is held close to the eye. The fineness and certainty of distance perception depend greatly upon the continuity of the visual field from the feet of the observer to the object viewed, and in the last mentioned case the obscuration of this sense is due to the interruption of these conditions. In the case of myopic glasses the illusion is due, in part at least, to an underestimation of the distance of the objects, resulting from their abnormal definition as seen through the stronger glasses. In any series of uniformly spaced objects the apparent size and the visual distance between any two adjacent members decreases as their absolute distance from the eye increases. In all normal cases this decrease is correctly interpreted through the coördinated perception of increased distance. If, however, an illusion of increased nearness to the observer arises from any cause, not only do the objects themselves appear smaller, but the relative distances between them are likewise reduced, and the perspective of the field of individualized objects thereby diminished.

d. The faces of persons in the middle distance—that is, towards the farther limit of distinct vision for the character of the facial lines and expression—appeared to hang in the air near by when first caught sight of. Here the distance of the object appears to have been estimated correctly by the use of various familiar criteria, chiefly the multiplicity of objects between the observer and the person seen. When, however, the eye first rested upon the face of the person in question these cues fell into the background and the abnormal definition of the face became the dominant factor of the experience, a definition possible to the unaided myopic eye only within a much narrower range of vision; and the shock of contradiction between the felt distance of the object and its observed distinctness resulted in a dissociation of the face image from that of the rest of the body, the latter maintaining its estimated distance, the former approaching to that corresponding habitually with the observed definition. The illusion maintained itself only during a few moments while the attention was strongly centered on the face.

e. This focussing of attention upon the face had itself an abnormal element in it. The faces of persons at a distance appeared mask-like and grotesque; the eyes stared, the light and shadow fell unnaturally, the lines and expression were distorted. Subjectively this change was manifested chiefly as an alteration in the affective overtone of the object, but one which itself is derived from a change in the character of the perception. The magnitude of the visual angle which any object subtends varies with its distance from the observer. As this distance changes, the mechanism of the eye must be adjusted to keep the object in the focus of distinct vision. Up to a certain point this is possible, but beyond that limit accommodation of the eye must be replaced by approach of the point of view toward its object. The latter form of adjustment is habitual with the myopic eye as compared with the normal. In consequence the angle which the object of distinct vision subtends in the case of the myopic eye is habitually greater than in that of the normal eye. It

always sees things at a different angle—in other words, it sees a different *thing*. Suppose that for the normal eye A and the myopic eye B the ranges of distinct vision be respectively a b c and b c, and that there be viewed an object consisting of a set of plane surfaces at right angles to the line of vision of the normal eye and a second set coincident with it. The normal eye will habitually see only the set of plane surfaces at right angles to its axis of vision, and at successively greater distances from its point of view; while the myopic eye, observing the same object, will not only regard these planes at a different angle, but will see also the surfaces connecting the extremities of the first mentioned planes. In other words, the two eyes will have before them different sets of visual elements. The same principle applies in detail to all objects of distinct vision; therefore, as the point of view changes to a new focal distance from normal to myopic, or the reverse, the constituents of the visual field are altered and an accent of strangeness and unfamiliarity is given to its objects. This matter of focal distance becomes of distinct importance in photography, where the space relations of camera and object must be as nearly as possible those under which the picture will afterward be viewed; otherwise a distortion of perspective appears which materially interferes with the truth of the representation.

f. There is a final group of changes in visual perception to be considered in connection with concomitant motor adjustments. These consist, in the first place, of deflections and curvatures of right lines when viewed through the marginal areas of the glasses, which are obviously due to the non-homogeneous refractive qualities of the lens. They are identical with the distortion of vertical lines upon the sides of the visual field in a photograph the focal distance of which is short in relation to the length of these lines. The divisions of the sidewalk, the rails of the car tracks, and all lines whose direction lies at right angles to that of vision, are thus warped from the rectilinear. The same is true of house-walls and trees, and of all vertical lines at the sides of the visual field. When coming down a flight of stairs the steps curve forward at the sides, making them appear a semicircular, hollow flight.

The result of these changes is a confusion of the relations between visual perception and motor adjustment. The familiar visual cues by which the latter is habitually governed have been destroyed, and movements are awkward and mal-adjusted. It is impossible to walk down a familiar flight of steps without stumbling repeatedly. The illusionary reduction in visual size and foreshortening of perspective work disastrously here, and result in a short, mincing step which brings the foot constantly into collision with the step from which it is descending, instead of allowing it to clear for the next. There is an absolute contradiction between visual measurement and motor adjustment. The only way to secure such adjustment and reach the bottom in safety is to look quite away from the steps and to trust wholly to joint and limb perception. Thus the connections of muscular memory become the controlling cues, uncontradicted by present visual impressions, and the descent grows at once secure and rapid.

Secondly, the shortening of perspective is not uniform for all areas of the lens, but increases continuously from the margin towards the center. The effect of this appears in a curious optical illusion and a second form of mal-adjustment of motor reaction in consequence of it. The ground in front, as one walks, appears constantly to rise in a sharp curve, as if a steep hill were being mounted, and the foot is raised to meet the imaginary elevation, only to be brought down again with a shock to the original

level. It is a continual repetition of taking a step too many at the top of the stairs.

The most strongly marked characteristics of the whole experience lay in the change wrought in the affective overtone of perceptual objects in the suggestion of new touch-qualities and impulses, and the existence of abnormal emotional attitudes, but these matters lie too far afield to be considered in the present paper.

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*BIRDS AS WEED DESTROYERS.**

A MILLION weeds can spring up on a single acre. Cultivation will do much to eradicate these noxious plants, but some will always succeed in ripening a multitude of seeds to sprout the following season, so as to make tilling the soil an everlasting war against weeds. Certain garden weeds produce an incredible number of seeds. Thus a single plant of purslane may mature a hundred thousand seeds in the fall, and if unchecked would produce in the spring of the third year ten billion plants.

Probably the most efficient check upon this unbounded increase of seeds is to be found in the seed-eating birds which flock by myriads to agricultural districts to feed upon the bounty of the weed-seed harvest from early autumn until late spring. Since birds attack weeds in the most critical stage of the plant cycle, it follows that their services will be of actual practical value. The benefits are greatest in case of hoed crops, since here found the largest number of annual weeds, which, of course, are killed by frost and must depend for perpetuation solely upon their seeds. Seed-eating species of birds prevent, in a large measure, weeds of this class, such as, for instance, ragweed, chickweed, purslane, crab grass, pigweed, lamb's quarters and several weeds of the genus *Polygonum*, from seeding down the land with a rank vegetation fatal to cultivated crops. The problem of weed destruction is of such magnitude that Mr. F. V. Coville, Botanist of the United States Department of Agriculture, in discussing weed legislation, has said, * * * "Since the total value of our principal field crops for the year 1893 was $1,760,489,273, an increase of only 1 per cent., which might easily have been brought about through the destruction of weeds, would have meant a saving to the farmers of the nation of $17,000,000 during that year alone."

The birds most actively engaged in consuming weed seed are horned larks, blackbirds, cowbirds, meadow larks, doves, quail, finches and sparrows. In a field sparrow's stomach I found 100 seeds of crab grass, in a snowflake's stomach 1,000 seeds of pigweed, and in a mourning dove's crop 7,500 seeds of *Oxalis stricta*. That the destruction of weed seed by birds is extensive enough to be of considerable benefit to the farmer is shown by Professor F. E. L. Beal, who estimated that in the State of Iowa alone a single species, the tree sparrow, consumes annually 875 tons of weed seed.

From the examination of the stomachs of some 4,000 birds it has been determined that the best weed destroyers are the goldfinches, grosbeaks and a dozen species of native sparrows.

In cities the English sparrow, assisted by several native species, does good work by feeding upon the seeds of lawn weeds, such as crab grass, pigeon grass, chickweed and the dandelion. On the lawns of the Department of Agriculture, in Washington, the birds feed upon dandelions from the middle of March until the middle of August. After the yellow petal-like corollas have disappeared, and the flower presents an elongated egg-shaped body, with a downy tuft at the upper end, the sparrow re-

* Birds as Weed Destroyers. Year-book of Department of Agriculture for 1898, pp. 221–232 inclusive.