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cases, 89 per cent of the color cases, and, as I have said, 92 per cent of the newspaper cases. At nearer distances we find the remarkable uniformity with which the *safe-distance* association works. At 14 inches only 14 per cent of all the cases were refused, and at 13 inches only about 8 per cent. The fact that there was a larger percentage of refusals at 11 and 12 inches than at 13 and 14 inches is seen from the table (I.) to be due to the influence of the brown, which was refused consistently when more than 10 inches away. The fact that there were no refusals to reach for anything exposed within reaching distance (10 inches) — other attractive objects being kept away — shows two things: (1) the very fine estimation visually of the distance represented by the arm-length, thus emphasizing the element of muscular sensation in the perception of distance generally; and (2) the great uniformity at this age of the phenomenon of "sensorimotor suggestion"¹ upon which this method of child study is based.

In regard to the relative use of the two hands in these and other experiments, — this is a topic to which I wish to devote another paper, giving details upon which certain conclusions (announced in an earlier note in this journal) are based.²

LETTERS TO THE EDITOR.

*** Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.

On request in advance, one hundred copies of the number containing his communication will be furnished free to any correspondent.

The editor will be glad to publish any queries consonant with the character of the journal.

The Convex Profile of Bad-Land Divides.

UNDER this caption Professor W. M. Davis, in *Science*, Oct. 28, 1892, discusses the "missing factor" in Gilbert's "Law of Divides," and concludes that it is "the creeping of the surface soil."

In my class-room lectures, and in a paper forwarded four months ago to the secretary of the Geological Society of America, but not yet published, I also have attempted an explanation of this missing factor. I mention this merely for the truth of history, not that I care much for the credit of priority, or fear the charge of plagiarism when my explanation appears. Its independent origin will be self-evident, because I have approached the problem in a very different way.

Both Professor Davis and Mr. Gilbert seem inclined to regard bad-land forms as something apart from land-sculpture in general — something which requires special explanation — while I have cited general laws and deduced these forms from them. My paper is entitled "Some Elements of Land-Sculpture: Water Curves, Weather Curves, and Structural Angles." Water curves are either horizontal, e.g., the serpentine course of a river, or vertical. The vertical water curve of erosion is concave upwards, e.g., the normal gradient of a stream excavating its channel in homogeneous material (b.c. Fig. 3); and the vertical water curve of deposition is convex upward, e.g., a *débris* fan, or alluvial cone.

All weather curves are convex upward. This fundamental law of the weather curve I have deduced theoretically in two ways, and that it is confirmed by observation almost goes without saying. An angular structural block, A, Fig. 1, is rounded by

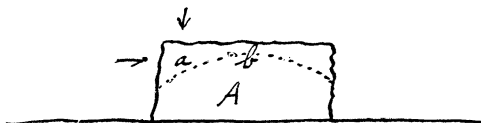


FIG. 1. — A structural block rounded by weathering. The dotted line is the weather curve, convex upward.

weathering, that is, its outline becomes a flowing curve, convex upward, like the dotted line in the figure, because the protruding angles are more exposed to attack, and at the same time the products of disintegration are in a position to be quickly removed.

¹ See my article on "Suggestion in Infancy," *Science*, xvii., 1891, p. 113; also my "Handbook of Psychology," Vol. II., pp. 297 ff.

² *Science*, xvi., 1890, p. 247.

The complex forces included under the general term weathering have a double advantage at *a* as compared with *b*, because the attack comes from two directions. Moreover, the removal of loosened particles, whether by falling raindrops, by winds, or by gravitation (one effect of which is creeping), proceeds many times faster at *a* than at *b*. By a similar but slightly modified process of reasoning, it may be shown that a sharp crest triangular in cross-section would be rounded also by weathering (c.f. La Noé and Margarie, *Les Formes du Terrain*).

Another method of deducing the upward convexity of weather curves is that which is based upon the law of slopes in relation to hardness. The harder the rock the steeper the slope, other things being equal. Let 1, 2, 3, and 4 (Fig. 2) denote strata which grade regularly downward in hardness, No. 1 being hardest of all. Then if the products of disintegration are at once and completely

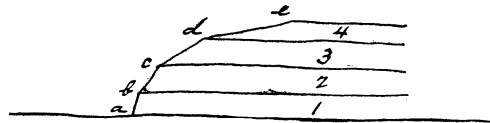


FIG. 2. — Convex slope formed by the weathering of rocks which regularly increase in hardness downwards.

removed, as, for instance, by a stream flowing at *a*, the hard rock, No. 1, will form a cliff *ab*, while *bc* will be less steep, *cd* still less steep, and *de* very gentle. Each element of the slope, e.g., *bc*, is a straight line in cross-section, but the general effect is that of a curve; and if the beds were very thin it would pass from a broken line to a true flowing curve, convex upward. Now we may conceive the series 1, 2, 3, 4 to have been originally homogeneous, and that weathering has softened the upper members. In that case the downward gradation in hardness would be by infinitesimal laminae, and the resultant slope a typical weather curve.

Ordinarily, the convexity does not extend to the bottom, because the weather curve is there replaced by the vertical water curve of erosion. This combination of weather and water curves modifying structural blocks yields the form shown in Fig. 3, the

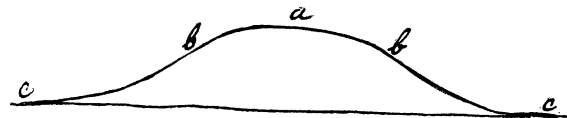


FIG. 3. — Cross-section of any ordinary ridge or hill.

most typical, as it is also the most familiar and universal of earth-forms. The upper part, *ab*, of each slope is a weather curve, convex upward, and the lower part, *bc*, is a water curve, concave upward. Bad-land divides are excellent examples of the general law, instead of being exceptions to it. The convex profile of the summit which puzzled Gilbert is simply the familiar and omnipresent weather curve. The only thing exceptional about it in the bad-lands is its narrowness and sharpness of curvature. That depends chiefly upon the early stage of the base-levelling in those regions, as I have shown in my forthcoming paper.

Creeping is a real factor in the rounding of divides, but is only one phase of the secondary process of transportation. Disintegration is the primary process. And in the subsequent movement of loosened particles, falling raindrops, gusts of rain driven aslant by winds, the winds themselves, the rolling and tumbling effects of gravitation as distinguished from the slow process of creeping — all these are active and efficient agents of removal. Their combined effects overshadow the results of creeping, especially on the bare, sharp ridges of the bad-lands. The clays are compact and firmly adherent. It is on gentle and turf-bound slopes that the slow process of creeping is relatively most effective.

Nor do I agree that the weather curve on the summit of bad-land ridges would be obliterated if the rainfall should increase. The effect of falling raindrops belongs to the category of weathering, and produces convex curves. It is only when the fallen drops gather into rills and begin to flow that the concave water curve of erosion begins to form. Hence increased rainfall would

probably strengthen rather than obliterate the weather curve, especially when we consider the effect of increasing vegetation which would follow increased rainfall.

L. E. HICKS.

Lincoln, Neb., Nov. 4, 1892.

The Moon's Atmosphere.

IN *Science* of Feb. 24, Sir Robert Ball makes application of the kinetic theory of gases to explain the absence of air from the moon. He observes that, although the mean molecular velocity of translation is less than that required by a body projected vertically from the moon to overcome the moon's attraction, "in the course of their movements, individual molecules frequently attain velocities very much in excess of the average pace," and would therefore be able to escape from the moon into space, and thus, in time, the whole atmosphere would be lost. I think a full consideration of the subject will not justify that conclusion, but that we shall be obliged to resort to some other physical laws to solve this old problem of speculation.

The kinetic theory requires all the molecules of a gas to have equal masses, equal energies, and hence equal mean velocities. This mean velocity for the hydrogen molecules at 0° C. is about 1,800 metres per second, while that of oxygen and nitrogen is about 450 metres per second, since the velocity is inversely proportional to the square root of the mass of the molecule. To overcome the moon's attraction a body must have a vertical velocity of about 2,200 metres per second. But it must be remarked that the escaping molecules, if there are such, are only those of the outer confines of the atmospheric envelope, where the mean free path of the molecules is relatively very great, as suggested with respect to the earth's atmosphere by H. Daniells ("Principles of Physics"), and the temperature of those regions is very low. If the temperature is about 68° absolute scale (−204° C.), as assumed by some authorities, the mean molecular velocity falls to about 225 metres a second, since the velocity varies as the square root of the absolute temperature. The vertical velocity, then, or the vertical component of the velocity must be about ten times the mean velocity to balance the force of gravitation, which is not probable.

Again, if the temperature is much lower than 68° absolute, approximating the absolute zero, and the molecular velocity always obeys the law before mentioned, the velocity also would approximate zero, and of course the molecules could not escape the attraction. It appears, then, to be largely a question of the temperature of the outer limits of an atmosphere. With this in view, let us compare results on planetary bodies of different size and stage of world life. As already suggested, with respect to the earth and moon, the earth's attraction at the surface is about five times that of the moon at its surface. This, *ceteris paribus*, would require about five times greater molecular velocity of its atmosphere to escape than for that of the moon. But, if we take into account the previous history of the two bodies, it is observed that the earth was highly heated for ages after the moon had become comparatively cool, and this must have rarefied and expelled its atmosphere to great heights, and maintained a temperature in those regions which, according to the proposition under discussion, would have caused the earth to lose its atmosphere. In general, it would follow that the major planets and larger satellites would lose their atmospheres more completely while cooling than the smaller ones, unless they have correspondingly greater quantities of volatile matter in their composition than the smaller ones. And such seems to be the result. Even Jupiter, whose attraction at the surface is 2.6 times that of the earth, is believed to have an atmosphere much less extensive proportionately than the earth. Mars offers a good example of a small planet with a copious atmosphere. Its attraction is only about twice that of the moon. Why has he not lost his atmosphere? If the application of the kinetic theory alone explains the loss of the moon's atmosphere, it would require Mars to have suffered the same fate before now. Possibly we are committing the error of the Greek philosophers in treating molecules as independent masses instead of regarding them as inter-dependent centres of activity whose phenomena, as a system, constitute the qualities of matter. I do

not assume to offer a solution for this complex problem, but hope rather to encourage discussion which will call out all the principles of physical science applicable to it.

W. H. HOWARD.

Adrian College, Adrian, Mich., April 15.

Note on the Crystalline Lens of the Eye.

MR. McLOUTH'S observation upon "A Peculiar Eye," as observed by him in "a domestic animal," given in *Science*, No. 531, would have been considerably enhanced in value had he recorded at the same time what that "domestic animal" was; whether it was an anserine fowl, as a duck or goose; or a gallinaceous one, as a hen, turkey, peacock, or guinea-fowl; or whether a carnivorous mammal, as a dog, or a cat; or an *Equus*, or a *Bos*, or a *Sus*, or an *Ovis*, or what not.

To the minds of some, the so-called "domestic animals" form a natural group, and even such an authority as Girard was so blind as once to propose a *special* classification for the domesticated mammals! It is not uninteresting to trace the origin of this idea, associated as it is in a way with the kindred one of man holding a place apart from the rest of organized beings.

It is only necessary to invite Mr. McLouth's attention here to the fact that the crystalline lens in the eye of man consists of *three* triangular segments, and their existence is easily demonstrated by immersion of the lens in strong alcohol, or by boiling it. The apices of these three segments are at the centre of the lens, in *front*; their bases in the circumference. Another structural feature of the lens is seen in the laminae of which it is composed. The treatment just proposed demonstrates these also, consisting, as they do, of concentric layers, which are firm at the centre, but become softer as we approach the peripheral ones. Likewise, by thus treating the crystalline lens from the eye of a horse, we prove that it also divides into its concentric laminae, and its *three* triangular segments. But whether this holds true in the case of all vertebrates has not, I think, been demonstrated. Very likely the crystalline lens of the "domestic animal" examined by Mr. McLouth had been submitted to a process which had a similar effect upon it as boiling or immersion in alcohol would have had, and simply exhibited its normal structure. From what I can gather from the communication of your correspondent in *Science* there was nothing abnormal about the lens of the eye he examined.

R. W. SHUFELDT.

Takoma, D.C., April 14.

The Aurora.

IN *Science* for April 7, at page 186, certain statements of mine in regard to auroral effects proceeding from the sun's eastern limb are called in question. It would have been much more satisfactory if these criticisms had given evidence of such familiarity with the subject as would be shown by the mention of even a single date on which it might be claimed that an aurora appeared in the absence of well-defined solar conditions of the character indicated. Except where specific mention is made of such individual instances, the writer proposes to refrain from discussion, which would readily become interminable as well as utterly inconclusive. Such results as those of Professor Ricco, recently announced in *Astronomy and Astro-Physics* and elsewhere, it is a pleasure to meet with and comment upon. He simply takes the case of the great magnetic storms of 1892, which were eleven in number, and studies the coincident solar conditions, especially with reference to the location of spot groups at the meridian. In seven out of the eleven instances he finds that there were such groups on the meridian, but that the magnetic effect, if it proceeded from them at all, was not felt for a varying period of from twenty-one to fifty-one hours subsequently. If, however, he had gone further and inquired what there was at the eastern limb on these dates, he would have found that there was a spot group in that location in every one of these instances without any exception whatever, and that these groups were located upon areas which were much disturbed at successive returns by rotation. Moreover, there was in these instances no appreciable retardation or variability of retardation, the magnetic storm being in progress