The well is six inches in diameter, and sufficient water was obtained to make it a success.

The other well is at the pump-house of Bischoff's Brewery, some 500 feet east of the most eastern serpentine outcrop at the foot of the hills. This has now (Dec. 1st) reached a total depth of 210 feet, and the boring is still unfinished. The section thus far has been as follows:

Glacial drift.....80 feet.
Various kinds of tough hornblende schist, apparently varying to serpentine,....130 feet.

As yet no gneiss nor granite has been reached.

An outcrop of clay occurs near Clifton, about three-fourths of a mile south of the Forts, near the southern edge of the terminal moraine; it has been found, by borings made by Mr. Charles Townsend, in excavations for cellars, to be at least ten feet in thickness, and of a light color.

The clay is probably of Cretaceous age, and if so, this is the most eastern point at which beds of that age are known on Staten Island.

Mr. W. T. Davis has recently observed a large fossiliferous boulder of Schoharie Grit on the shore at Brighton Point. The fossils have been submitted to Dr. Newberry, and the following species identified:—*Dalmanites anchiops*; *Orthoceras Pelops*, *Strophodonta hemispherica*; *Atrypa reticularis*; *Strophomena rhomboidalis*; a *Fenestella*; and *Zaphrentis prolifera*.

Glacial groovings have recently been noticed on the hornblende-rock, which is exposed at tide-level on Brighton Point. Some of the grooves are at least one-quarter of an inch in depth, three inches wide and four feet long. Their bearing varies from N. 15° W. to N. 17° W.

DISCUSSION.

Prof. D. S. MARTIN considered the specimen of so-called hornblende schist from the well-boring, not to consist properly of that rock, but to be partly hydrated—apparently a less altered condition of the rock which higher up gives us the soft, semi-fibrous serpentine of the island.

Dr. NEWBERRY regarded the serpentine of Staten Island as probably a pseudomorphous condition of hornblende slate. It differs considerably from the mottled serpentine of New York Island, which is "verde antique"; that is, is composed partly of serpentine and partly of carbonate of lime, and is scarcely distinguishable from the Moriah marble, which is quarried at Moriah, Thurman, etc., in the Adirondack region. It is a peculiar rock, and one of the connecting links between the rocks of New York Island and those of northern New York and Canada. Taken together, these afford strong indications of the Laurentian age of the New York Island and Staten Island crystalline rocks.

Dr. Newberry further said that the accurate determination of the age of the rocks of New York Island, of Staten Island, and of those underlying the drift of Long Island, was in the highest degree desirable and important; and while he was satisfied that the former were Laurentian, and the latter Cretaceous, it was eminently desirable that unquestionable proof should be found of this, if it is true. At present no positive assertions could be made, and the duty devolves on the geological members of the Academy to rid the subject of doubt.

The fossils in the boulder referred to by Mr. Britton prove to have come from the Schoharie Grit. In its original condition this was a hard, compact blue limestone, but is here presented in a leached state, by the passage of waters containing carbonic acid, with a loss of its lime, color, and density. It was derived from northern New Jersey, to which locality a belt of this rock runs down from Schoharie county. Its transit by ice was effected without doubt through the valley of the Hackensack, which lies east of the Orange Mountains and west of the Palisades. This glacial movement is indicated by the direction of the striæ observed by Mr. Britton, as well as by those in the Hackensack valley.

Mr. A. A. JULIEN recalled the results of his lithological examination of the serpentines both of Staten Island and of Hoboken, presented before the Academy two years ago, in which it was shown that sections of all these rocks abounded in minute fragments of more or less altered amphibole. The conclusion then stated, that these serpentines must be certainly derived from hornblende schist, was confirmed by the interesting discovery of the latter rock, both in well-boring and on Brighton Point. Serpentines of the same general character and origin occur frequently throughout New York and Westchester counties. The mineral serpentine is also found in small quantity as a vein-deposit, not pseudomorphous, like the main mass, but presenting an amorphous material with banded vein-structure, associated with magnesite, dolomite, etc.; e. g., the marmolite of Staten Island, a translucent green variety found at Hoboken, and also at West 60th street on New York Island, etc. At all these localities the amphibole survives in a more or less altered condition; e. g., the tremolitic talc schists and slaty tremolitic serpentines of Staten Island and Hoboken, the hydrous anthophyllyte and unaltered tremolyte rock of West 60th street, New York, the tremolitic amphibolyte of New Rochelle and Rye, in Westchester county, etc.

Mr. BRITTON confirmed the last remarks, by the statement that a vein of material, strongly resembling the hydrous anthophyllyte of New York, had been struck at the bottom of one of the wells on Staten Island; also that veins of mixed serpentine and calcite were observed at Stapleton, possessing a banded structure parallel to their walls. At that point the apparent thickness of the serpentine bed is 150 feet, but the crest of the hill is composed of talcose schist.

MR. W. LE CONTE STEVENS then read a paper on "THE MAMMOTH CAVE OF KENTUCKY,"

He also exhibited specimens of the blind fish (*Amblyopsis spelaeus*), and blind crawfish (*Cambarus pellucidus*), and stereoscopic views of various points in the interior of the cave.

(Abstract.)

At the close of the Cincinnati meeting of the American Association for the Advancement of Science, in August last, he was one of a party of seventy-five members who visited the Mammoth Cave, remaining there two days, during which the greater part of the time was spent in exploration. He made no claim to new discoveries, but wished to call the attention of the Academy especially to recent observations, for the most part by Rev. H. C. Hovey, of New Haven, in regard to the temperature and structure of the cave. Mr. Hovey read a paper on this subject in Cincinnati, only a brief abstract of which has yet appeared in print, making use of a map, which is the first of its kind ever exhibited. The strictest precautions are observed by the authorities controlling the cave to prevent visitors from taking surveying instruments in with them: but the present manager, Mr. Francis Klett, has made a careful survey of the most interesting parts, and in time this will probably be given to the public, though possibly the scale of measurement may be withheld.

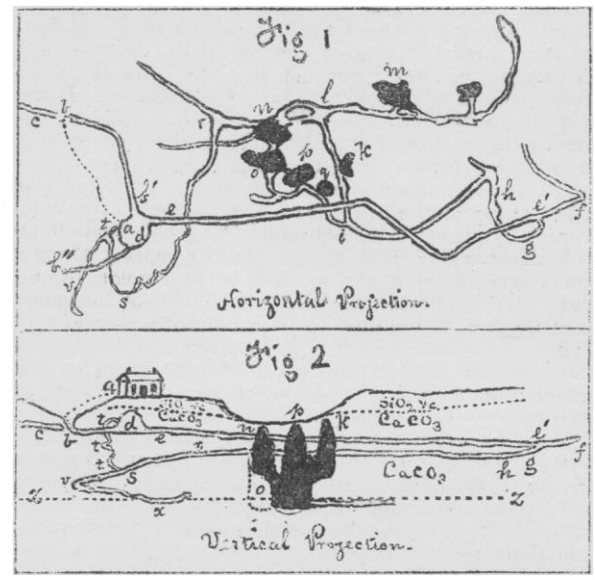
The central and right-hand portions of the map exhibited by Mr. Stevens had been enlarged by him from a copy of Mr. Klett's map. The left-hand portion was drawn only from recollection of the localities traversed, and not to scale, being intended only to illustrate principles. The same remark applies to the vertical projection, the lettering of which corresponds with that of the horizontal projection.

The temperature observations of Mr. Hovey were con-

ducted with much care, and the very best instruments had been confided to him by the Director of the Winchester Observatory at New Haven. In August, 1881, while the external temperature at the neighboring hotel varied between 90° F. and 100° F., at points farther than 100 yards within the cave, the reading of the thermometer was never more than 56° nor less than 52½°, the mean temperature being 54° for the summer months. At a point 1,000 yards within, a thermometer had been left for six months, including the autumn and winter, and daily visited by Mr. Klett, who reported the variation to be only from 54° down to 53°. The underground temperature in this latitude, for points 60 or 70 feet below the surface, is usually assumed to be constant and about the same as the mean annual temperature above. According to Prof. Guyot's maps, the isotherm of 60° passes about thirty miles south of the Mammoth Cave, while that of 50° passes about forty miles north of Cincinnati. The temperature of the Mammoth Cave is fully 6° lower than has been commonly supposed, and may be taken as a fair representation of that of the crust of the earth in the country immediately surrounding it.

Mr. Stevens exhibited a geological map of Kentucky, showing the area of sub-carboniferous limestone in which the Mammoth Cave is situated. This is overlaid with a thin stratum, mostly of sandstone, that is pierced by thousands of sink-holes, through which the surface drainage is carried down into limestone fissures and thus to the general drainage level of the Green River. This stream passes at the distance of less than a mile from the Cave Hotel, the floor of the latter being 312 feet above the water and 118 feet above the mouth of the cave. He briefly explained, with a diagram, the general mode of cave-production in limestone strata, showing that subterranean tunnels must be started by the solvent action of slightly acidulated rain-water, and subsequently enlarged by erosion, along the fissures in the limestone. These agencies are still at work in portions of the cave, and the whole of this limestone country is thus honey-combed with caverns. No tunnel can be thus formed at any point lower than the general drainage level, since there must be an exit for the saturated water. The production of the fissures is referable to the general upheaval of this area at the close of the coal period: but, that there has been subsidence since the completion of much of the Mammoth Cave, is indicated by the fact that at its lowest parts to-day the floor is covered with water to the depth of thirty feet or more, having subterranean connection with Green River. The fissures intersect at various angles, but many of them are nearly or quite coincident with the dip of the strata, which is very gentle. Water passing through these forms the tunnels, while that passing through the vertical fissures scores out the pits which pierce them. The same pit, starting from a sink-hole at the surface, may have successively lower tunnels as exit passages. If the visitor encounters it while walking through the higher, and therefore older, tunnel, the upper part appears to him as a dome, the lower as a pit.

The rate of erosion in the Mammoth Cave has been variable. The older parts are perfectly dry, and entirely free from stalagmitic deposits, indicating rapid erosion, followed by elevation, so as to deviate the water completely into other channels. In the newer parts the water is still dripping from the surface above, and depositing stalactites and stalagmites; but as a whole the cave is by no means remarkable for these formations, being much surpassed in this respect by the neighboring White's Cave, of more recent origin. Those which do occur are moreover deeply colored with iron, which exists in the soil in the form of both oxide and sulphide. In the dry parts, the ceiling of the cave is more or less covered with efflorescent calcic, magnesic and sodic sulphates, which contrast with the iron-stained limestone, giving rise to the beautiful effects that have conferred celebrity on the opening known as the Star Chamber, and the myriad rock flowers of Cleveland's Cabinet.



The structure of the pits and domes was then illustrated with the aid of the accompanying map, by describing a journey through the cave. From the hotel, (*a*, figures 1 and 2,) the visitor walks to its mouth (*b*), by the side of a shallow ravine, terminating in what was formerly a large sink-hole. The door of this fell through, about seventy years ago, producing the present mouth of the cave, and cutting off part of the gallery, now known as Dixon's cave (*c*), which opens out near the Green river, a half mile distant. A walk of 1000 yards brings him to the Great Rotunda (*d*), about 170 feet in diameter and 100 feet high. It is immediately under the hotel, its roof being not more than 40 or 50 feet from the surface. Besides the gallery, called the Narrows (*b'*), by which access has just been obtained, another tunnel from the further side terminates in the Rotunda, to which the name of Audubon's avenue (*b''*) has been given. The large, almost hemispherical opening, seems to have been cut out by the meeting of nearly opposite streams of water, which found exit, probably, through the main cave (*e*). At some distance within Audubon's avenue, a small opening in the floor is found, connecting it with the roof of the Mammoth Dome, a vast cavern 400 feet long, 100 feet wide and 250 feet high. These figures are of course only approximate, but it is believed that they are not exaggerated. Into this cavern the water is still trickling, and stalagmites are forming with sufficient rapidity to have cemented firmly to the floor a lamp dropped in 1812 and found in 1843. Returning to the Rotunda and passing through a half mile or more of the main cave, the visitor reaches, at *e'*, a large fallen slab of limestone to which has been assigned the title of "The Giant's Coffin." This makes the entrance to a side passage (*g*) which leads off to the lowest part of the present cave. The main cave forms an acute angle (*f*) and may be followed for several miles, terminating abruptly in a pile of rocks, where the roof has fallen in the same manner as at the terminus of Dixon's cave. Many of its side passages and avenues are yet unexplored.

Returning and entering the side passage near the Giant's Coffin the visitor passes obliquely beneath the main cave, starting upon what is known distinctively as the Long Route. At an expansion (*h*) are successive deposits of gravel, sand and clay, indicating the downward course of the water which was here partially arrested.

Some distance further on, the passage forks (*i*). Keeping to the right, the dangerous Side Saddle Pit (*k*) is encountered, which measures 65 feet in depth and 20 feet across. It is surmounted by Minerva's Dome, 35 feet high. The pit yawns across the right half of the floor of the tunnel, leaving a narrow path on the left. A short distance beyond (*l*), the tunnel again forks. Keeping to the right as before, Gorin's Dome (*m*) is reached, and may be viewed with the aid of magnesium lights, from a small opening on the side, ten feet above the pathway. The abysm extends 117 feet downward, 100 feet upward and 60 feet across. Leaving this and passing the fork (*l*), the tunnel is completely interrupted by the so-called Bottomless Pit (*n*) across which a bridge has been laid, resting upon a ledge. Despite its ominous name it does not defy measurement, having been found to be 95 feet deep on one side of the ledge and 105 feet on the other. Almost immediately overhead is Shelby's Dome, 60 feet high. Between the Bottomless Pit and Side Saddle Pit are a pair of very large pits, discovered not a year ago by one of the guides, William Garvin, and examined for the first time last August by Mr. Hovey, who gave to them the names Scylla (*p*) and Charybdis (*o*) on account of the narrow, rugged passage which separates them and the great difficulty and danger of access. By timing the fall of pebbles into the water at the bottom, the depth of each was ascertained to be about 200 feet. Charybdis was seen to be directly connected with the Bottomless Pit. Indeed the latter may be regarded as only a part of Charybdis, its depth, 105 feet, being only that of a jutting ledge, or the floor upon which water ceased to fall after being slightly deviated into Charybdis, where the sound of its trickling is still audible. Shelby's Dome is simply the upward continuation of this combined pit. So narrow, moreover, are the ridges separating Scylla from Charybdis on the one side and from the Covered Pit, (*q*), on the other, and so small is the distance to the Side Saddle Pit (*k*), that it seems in the highest degree probable that this group of pits compose merely the upper branches of a single large pit into which they are all united, or at least directly connected before the bottom is reached, and the small relative depth of the Side Saddle Pit is explicable in the same manner as that of the Bottomles Pit. Such an extraordinary group of pits, forming an apparent nucleus of cave drainage, might be expected to have its counterpart in an unusually large depression, or group of sink-holes, at the surface. Impressed with this idea, Mr. Hovey found in the woods, scarcely half a mile from the Hotel, in the known direction of these pits, a depression (*p* Fig. 2.), many acres in extent, and so deep that from its edge he could overlook the tops of the pine trees that rose from the middle.

Leaving this region of pits and domes, the route leads still downward, passing again under the main cave through the narrow tortuous channel known as "Fat Man's Misery" (*s*) where the distance from floor to roof is in many places not more than three feet. Through the floor a winding passage has been worn away, varying in width and depth from one to three feet. This terminates in a chamber which has received the appropriate name of "Great Relief," where the succession of pebbles, gravel, sand and fine clay again records the work of erosion and deposit. This bed is not more than 50 or 60 feet above the drainage level, and from here down to the River Styx, the ground becomes more or less damp. A succession of bodies of water are then encountered, including the tubular Echo River, which is navigated in boats. It is a part of the tunnel which has subsided below the water level, and is in connection with Green River, being filled to within a few feet of the roof in summer, and completely closed in winter when the Green River rises. The column of air between the water and the impervious roof, closed everywhere except at the two ends, which are three-fourths of a mile apart, serves as a resonator for any note within the range of the human voice, and multiple echoes gliding imperceptibly into each other, continue to be returned for many seconds after the voice has been hushed.

Beyond Echo River, the cave may be followed, with continual ascent, through Silliman's Avenue, the Pass of El Ghor and Cleveland's Cabinet, for about five and a half miles. A pile of jagged rocks, 100 feet high, is then surmounted and the wearied climber is confronted with a large cavern, 100 feet wide and 70 feet deep, where three short branches have united in one tunnel. Following the left branch for a few yards, a hall is found, in the floor of which is a pit 175 feet deep. The corresponding dome overhead is scarcely noticeable as such, for the surface of the ground is not more than 30 or 40 feet distant. The end of the Long Route has been reached.

In returning, the passage through Fat Man's Misery is avoided, and nearly two miles of walking are saved by climbing through a very steep, narrow, winding "Corkscrew" pass (*t*, Fig. 2), starting from the neighborhood of Great Relief and terminating at the side of the Great Rotunda. The vertical ascent is about 140 feet. To even stout-hearted mountaineers, if stout-bodied also, this Corkscrew is an intensified Fat Man's Misery, and upon them it rarely fails to leave strong and deep impressions, which may be of more kinds than one.

In regard to the animal life of the Mammoth Cave, conflicting opinions have been expressed by those who have made a special study of this subject. The bats, lizards and rats that have been found cannot be strictly called cave-dwellers, as they are always at points not so far removed from the outer light as to make this inaccessible, The cave crickets and blind crawfish have particularly long antennae and acute powers of hearing. Most of the crawfish are pale in color, some of them almost white; and this feature has been attributed to the continued absence of light. Crawfish, however, with well developed eyes and of dark color have been often found. These are without doubt either wanderers from Green River or the immediate descendants of such; and many generations of cave-dwelling are required to bring about such changes as have caused the application of a specific name, *Cambarus pellucidus*, to the white variety with only rudimentary eyes.

In regard to the blind fish it is a significant fact that the rudimentary eyes of the young are apparently less atrophied than those of the mature fish. Although to these cave dwellers also a specific name, *Amblyopsis spelaeus*, has been given, they are by no means the only fish found amid this stygian darkness. The existence of fish with perfect eyes, apparently prospering where eyes are useless, shows how much less dependent these creatures are than more highly organized vertebrates upon approximate uniformity in external conditions. To those who have already accepted evolution, there is far less difficulty in believing that the colorless blind fish are the modified descendants of dark-colored ancestors with perfect eyes, which have wandered from Green River into Echo River, than in concluding that they have always constituted a separate species, as held by Prof. L. Agassiz, and subsequently contended by Prof. F. W. Putnam.* Nevertheless, Prof. Putnam has shown that the differences between the blind fish (*A. spelaeus*) and their nearest living congeners are much more than in respect to mere color of skin and power of vision. Whether the internal anatomical differences on which he reasonably lays much stress can be proven to be a natural result of the external conditions imposed by cave life, is a question which, if settled at all, must be settled by zoologists alone. Prof. A. S. Packard, Jr., and Prof. E. D. Cope are as pronounced in their opinion that the blind fish have been evolved from fresh-water ancestors possessing good vision, as is Prof. Putnam in the opinion that their ancestry were denizens of salt or brackish water, with which

* The Mammoth Cave and its Inhabitants. By A. S. Packard, Jr., and F. W. Putnam, Salem, Mass., 1879.

he believes that the cave was supplied at a time when this region was a salt or brackish water estuary. Prof. Putnam therefore concludes that the blindness of these fish has been in no respect a consequence of subterranean life.

DISCUSSION.

Mr. BRITTON inquired whether any flora existed in the cave.

Mr. STEVENS replied that, so far as he was aware, no kind of vegetation had ever been found within it.

Dr. NEWBERRY remarked on the geology of the region adjacent to the Mammoth Cave. The limestone beds of this high table-land are jointed in the manner common to rocks, apparently by some sort of polarisation, producing fissures which run in a north and south, and an east and west, direction. The plateau is about 500 feet above the drainage, part of the drainage passing into the Green River, and part into the Ohio. No streams occur on the surface and the drainage is quite gradual. At the angle between these two rivers several streams are seen, bursting out of the cliffs at various heights above the Ohio; they are, so to speak, subterranean sewers, representing the underground drainage of the country; at one point three such streams pouring out of the rock form very beautiful cascades; and near Sandusky a full grown river flows out of the cliff of cavernous limestone. The beds consist of lower carboniferous limestone, with sandy layers beneath. In the vicinity occur portions of the great "blue grass region," one of the oldest parts of the continent, once an extensive highland, forming an island in the sea. Around this, rims of sediments were deposited, consisting of sandstones and limestones; while on the other hand, the continuous process of erosion, during the lapse of a vast period, removed the material of the table-land within, and converted it into a broad depression or basin, the "blue grass region," above which the present plateau of the encircling sediments now rises to a height of 500 feet.

The erosion of the joints in this plateau has resulted in the formation of the pits described by Mr. Stevens, but it is probable that some of these may reach 200 or 300 feet below the Ohio and Green Rivers. There is evidence, from borings in the Delta of the Mississippi, etc., that the Continent was formerly more elevated, standing 500 to 600 feet higher at New Orleans than at present; the drainage was much freer, the Mississippi being a free flowing stream, as well as the Ohio and other tributaries. Borings have been sunk in the present trough of the Ohio river, to a depth of over 100 feet below its present bottom, without reaching the true bottom of the trough, the ancient bed of the river, which is perhaps from 100 to 200 feet further down.

Evidences of the same elevation of the continent were observed in caves on an island in Lake Erie. Long stalactites projected from the roof of a gallery whose end was ordinarily filled with water at the present level of the lake. At times a strong and steady wind has blown down the level of the lake and partially drained this gallery; but even then a guide, John Brown, resident on the island, has swum through the gallery and found the stalactites projecting from the roof as far as he could go.

In regard to the origin of the blind animals, the view of Prof. Cope is probably correct, that they have been derived from the degeneracy of ancestors who once had perfect eyes. No fish is formed with poor eyes; but any organ may be atrophied by disuse, with consequent feeble flow of blood, decreased nutrition, and inevitable shrinking of important parts. An analogy is shown in a comparison of the jaws of prehistoric and modern men. At present our "wisdom teeth" are useless, there is no room for them in the shortened under-jaw; our food being softened by cooking, cut up, and boneless, requires less vigorous mastication; and from disuse, and the consequently insufficient development, these teeth often speedily fall away. In the prehistoric man, on the contrary, the jaws were longer, roomier, supplied with more teeth—the "wisdom teeth" being well developed and kept in strength by constant use on coarse and rough food. The absence of the well-known stimulation produced by light, from the dark waters within the Mammoth Cave, has in the same way resulted in the atrophy of the organs of sight.

CORRESPONDENCE.

The Editor does not hold himself responsible for opinions expressed by his correspondents. No notice is taken of anonymous communications.]

To the Editor of "SCIENCE."

We can sympathize sincerely with the Editor of *The Popular Science Monthly* in his indignation at being held a promulgator of the views of "pronounced atheists," because of his publication of "the papers of Herbert Spencer, and others of his class." "Pronounced atheism" finds little place in the history of philosophy or science, as in the history of mankind and human civilization in general. And Dr. Youmans is certainly in the right with his emphatic denial that Mr. Herbert Spencer, in particular, pronounces himself an atheist and seeks to persuade others to do likewise. He "and others of his class" have, indeed, been very out-spoken in questioning the literal truth of many popular beliefs and sacred traditions. But that there is in "religious ideas" no "vital element," that they correspond to no fact and represent no truth, Mr. Spencer has been far from asserting. On the contrary, the precise opposite is most strenuously maintained by him (see especially Spencer's *First Principles*, Part I.).

And yet, while all this is verbally true, we fear that Dr. Youmans, in his just zeal to defend himself and his friend, both goes too far in his statement of the latter's real position, and forgets those grounds which lend color of justification to the perfectly sincere supposition of many thoughtful people, that the practical, if not the professed or intended, tendency of Mr. Spencer's philosophy, is in the direction of virtual atheism.

If it were really true that "no man of the present age has reasoned out the foundations of man's belief in the existence of the 'Infinite and Eternal Spirit' with such a depth of analysis and logical force as Herbert Spencer," if, as Dr. Youmans further declares, it were strictly true that Mr. Spencer "has sought to show that the 'Infinite and Eternal Spirit,' of which all the phenomena of the universe are but manifestations, is the most absolute of all realities," then religion would owe to him a debt of gratitude, which it is inconceivable that the intelligent defenders of religion should not gladly recognize and avow. But we are at a loss to know on what grounds the above assertions are made by the Editor of *The Popular Science Monthly*. Perhaps it is in esoteric discoveries, delivered to a select few of his admirers, that Mr. Spencer has "reasoned out" the aforesaid "foundations" and "sought to show" the pre-eminent absoluteness and reality of the 'Infinite and Eternal Spirit,' and Dr. Youmans's statements may have been made on the basis of what he has personally been privileged to hear of these discoveries, Thus the writer of these lines was once informed by an admirer of Mr. Spencer's, who had recently come from a personal interview with the philosopher, that the latter believed in "a God"—*supposing, not without a good deal of reason, that this would be a piece of news to one who knew of Mr. Spencer and his opinions only through his published writings.*

It is in the latter way, only, that Mr. Spencer is known to the general public. We, for our part, cannot claim for ourselves familiarity with every line which Mr. Spencer has ever written. But we have studied with great care and with great interest, what we supposed to be Mr. Spencer's of the redistribution of matter and motion. Some of these phenomena have indeed a *mysterious "obverse"*