THE

CHALK AND FLINT FORMATION

ITS ORIGIN

IN HARMONY WITH A VERY ANCIENT AND A SCIENTIFIC MODERN THEORY OF THE WORLD

ILLUSTRATED BY FACTS AND SPECIMENS

BY

W. B. GALLOWAY, M.A.

VICAR OF ST. MARK'S, REGENT'S PARK, AND CHAPLAIN TO VISCOUNT HAWARDEN

London

SAMPSON LOW, MARSTON, SEARLE, & RIVINGTON

CROWN BUILDINGS, 188, FLEET STREET

1886

Price Two Shillings and Sixpence.

THE

CHALK AND FLINT FORMATION

ITS ORIGIN

IN HARMONY WITH A VERY ANCIENT AND A SCIENTIFIC MODERN THEORY OF THE WORLD

ILLUSTRATED BY FACTS AND SPECIMENS

BY

W. B. GALLOWAY, M.A.

VICAR OF ST. MARK'S, REGENT'S PARK, AND CHAPLAIN TO VISCOUNT HAWARDEN

London

SAMPSON LOW, MARSTON, SEARLE, & RIVINGTON

CROWN BUILDINGS, 188, FLEET STREET

1886

LONDON:
PRINTED BY GILBERT AND RIVINGTON, LIMITED,
ST. JOHN'S SQUARE.

PREFATORY NOTICE.

As the few photographic illustrations which are introduced in the following pages, helpful as they are, afford at best only a defective and imperfect idea of the evidence, compared with the sight and examination of the numerous flint specimens themselves, these the writer will be happy to submit, as far as can be arranged, to the inspection of any one interested in the study, who will favour him with his card, and a call at such a time as he may be at home for the purpose.

LIST OF PHOTOGRAPHS.

1. Fragment of Tree Root in flint, showing part of the rotten interior of what had been decayed wood. (See pp. 11, 29, and 30.)
2. Fragment of Tree Root with Fungus adhering to it, in flint.
3. Fragment of Tree Root showing the decayed interior, and the outer bark partly separated from the inner wood, in flint.
4. A Bean Pod, small Bulbous Root, Gourd, and Pear or Fig not fully ripe, all in flint.—*Ibidem.*
5. Arrowy Flints. (See pp. 32, 33.)
   - (1.) Two which have touched and adhered together in their descent.
   - (2.) One which has come down upon two tabular layers of flint not yet hardened, pierced through the upper one, dinted out the lower, by the elasticity of which it has been partly forced back, drawing up the edges of the upper one with it.

The size in each case is considerably reduced from that of the specimens represented.

THE

CHALK AND FLINT FORMATION:

ITS ORIGIN, &c.

THE question of the origin of the Chalk and Flint formation cannot be considered as satisfactorily determined by any of the hypotheses which have been generally applied to the subject hitherto. One or two of these may be briefly stated.

It is a commonly-received theory that the chalk has been the product of the accumulated shells of minute infusorial animalculæ at the bottom of the sea; and that the flints have been in some way deposited from hot silicated springs, also at the bottom of the sea, on their coming in contact with reduced degrees of temperature. The manufacture of the chalk by those microscopic animalculæ is supposed to be going on at present at the bottom of the Atlantic.

In regard to the forms assumed by the flint there has been much difference of theory and conjecture. Dr. Bowerbank,[1] on examination of thin slices of flint under the microscope, thought he had ground

[1] Proceedings of the Geological Society, vol. iii., pp. 278 and 431: Trans. Geol. Soc., Series 2, vol. vi., pp. 181, 188, pl. 18.

for a conclusion which many have accepted from him, that flints were generally silicified sponges. I confess that my perusal of his papers and inspection of his illustrations did not appear to me to warrant that idea; which, I find, is disclaimed also by a more recent investigator, who, speaking of Dr. Bowerbank's researches and successive papers, says: "A vast number of interesting facts are here recorded; the author's generalization, however, that spongeous tissue is always present in flint, and has brought about its precipitation, though influencing many geologists even at present, has been objected to by others, and is not in accordance with the views of the author of this paper." The paper referred to is a valuable one by Professor T. Rupert Jones, F.R.S.[2] The same learned writer also rejects the idea, favoured by Dr. G. A. Mantell, of the flow of semi-gelatinous siliceous water over the sea bottom. But he has put forth another theory, that flint was formed by the very slow substitution of silica for amorphous lime and calcareous mud, atom by atom. In the case of organic forms, of whatever kind, he supposes that the original organized body had decayed and been replaced by lime and calcareous mud; and that these materials were then gradually displaced by silica, thus effecting a "creeping metamorphic change."

Later still Mr. R. Mortimer, in a careful paper on the Flints of the Chalk of Yorkshire,[3] has in turn

[2] "On Quartz, Chalcedony, Agate, Flint, Chert, Jasper, and other forms of Silica, geologically considered." Proceedings of the Geologists' Association, vol. iv., No. 7, p. 439.

[3] Proceedings of the Geologists' Association, vol. v., No. 6, p. 344. To this, and to Professor Jones's paper, my attention was specially and kindly called by Mr. S. R. Pattison, F.G.S.

expressed his rejection of the leading theory of Professor Jones,[4] and thinks "the direct infiltration (of silica) into susceptible cavities formed by organic decay" the more simple explanation; and this he supposes to take place "under certain conditions which (however) he does not venture to suggest." Now in considerable districts the chalk is found *without* flints; and there, Mr. Mortimer says, "this non-aggregation of silica in the flintless chalk is not due to the want of forms, the result of the decay of animal and vegetable substances, as sections will disclose shapes resembling every form of flint, even banded specimens. These forms, like the flints, are due to casts from cavities left by the destruction of organic substances." But since the chalk itself might thus fill those supposed vacant cavities, and take the cast of those forms, and has done so, as stated by Mr. Mortimer, the question arises, Why did it do so in some large tracts, but leave the cavities to be filled with the aggregation of silica in other large tracts, notwithstanding an equal, if not greater dissemination of siliceous particles (as he alleges) in the chalk of the flintless tracts? Of this there is no explanation given. There is, therefore, still good reason for a remark quoted by Professor Jones

[4] Mr. Mortimer's objections, which had presented themselves independently to me also on reading Professor Jones's paper, are stated by him as follows: "Since writing the above, the author has read Professor Rupert Jones's paper on 'Quartz, Chalcedony, Agate, Flint, Chert, Jasper, and other forms of Silica geologically considered.' The leading theory propounded he has difficulty in believing, and considers it should be shown how amorphous lime can be replaced by silica, while calcite and arragonite are not. Also that the whereabouts of the displaced chalk should be accounted for. In the Speeton-section of 350 feet, the flint is equal to twenty-four feet vertical." *Ibid.* p. 354.

in speaking of Dr. Bowerbank: "He would not pretend that the subject of silicification was at all mastered yet."

The conclusions which had been formed as to the chalk may be equally premature. Deep-sea soundings and dredgings have, in many instances, brought up chalk with microscopic shells and infusoria; but this may not prove more than that the chalk existing there had been made use of by these minute creatures as furnishing the material of their shells; just as hens take lime to furnish the material of their egg-shells, and, if they cannot obtain any lime, produce their eggs without shells. It no more follows that the microscopic marine animalculæ created the chalk, than that the hens created the lime of which their egg-shells consist. Chalk falling into the sea would speedily become animated with multitudinous forms of life there existing: and the rapid development of those forms of life is such as almost passes imagination. If under the microscope many portions of chalk exhibit minute marine shells, this would show that the chalk, where it abounds in these, had once lain as a deposit at the bottom of the sea, and had been so used while there: but if other portions of chalk should be found, not consisting of nor containing minute shells, this would again demonstrate the fallacy of such a theory of its origin. No doubt shell-fish derive the material of their shells from the sea-water containing a diffused portion of lime; but their shells are not properly chalk, nor, I apprehend, would any accumulation of their shells form a chalk cliff. On the other hand, if a stream of carbonic acid gas be passed through lime water, it will form a deposit of chalk quite without the intervention of marine insects; and if

a cloud of hot lime dust fell through an atmosphere abounding in carbonic acid, might not that have a similar effect?

Manifestly the hypothetical insect manufacturers of the chalk are both utterly incompetent to serve as a cause, and also wholly superfluous. Chalk may be got better without them.

The parallel case of limestone may be referred to for illustration. In a vast number of cases it consists largely of shells, as we see abundantly in many, if not most marbles; whence some geologists came to the conclusion that all limestones had originated in organized substances, and the eminent Dr. Macculloch adopted the opinion. On this Sir Charles Lyell expresses the following judgment: "When it is hinted that lime may be an animal product combined by the powers of vitality from some simple elements, I can discover no sufficient grounds for such an hypothesis, and many facts militate against it."[5] The same he might have said of chalk.

Moreover, how stand the grand facts of the Chalk Formation? It has, no doubt, in many cases been elevated from under the sea to those cliffs which now overhang it at considerable height, and are lashed by the waves at the base; and it presents abundantly fossil remains of fish and saurians. But the enormous masses of carbonate of lime are said to compose nearly one-eighth part of the superficial crust of the globe; and the chalk formation occupies extensive stretches of the land, across whole continents, and that in well-defined lines and breadths, reaching to great depths in the thickness of the deposit. It has been maintained, of course, that all

[5] Lyell, "Principles," vol. ii., p. 532, 10th Edition, 1868. See also his "Manual of Geology," p. 49.

these chalk lands were once the bottom of the sea. It may be so; but the sea is a diffusive element. How came the chalk deposit to be confined to those well-defined lines, and that for innumerable ages upon ages, while the supposed microscopic manufacturers were at work making it? The diffusive element of the water is assumed to have supported these operations only on certain limited breadths in well-defined lines, and not at all elsewhere; and this to the depth of hundreds of feet. Why not elsewhere? Again the Chalk Formation cannot be accounted for separately from the Flint. The chalk cliffs and some deep railway cuttings, exhibit the flints deposited in parallel horizontal layers, one layer above another, separated by intervening breadths of chalk. How came this about? The larger flints, when broken, are often found to contain portions of pure chalk in their interior, and this demonstrates simultaneous origin. But the microscopic shell-fish are not even supposed to have anything to do with the creation of the flints, nor with the deposit of them in those regular layers; nor is it explained how they made the chalk in the flint's interior. The flint under the microscope exhibits chalk in particles disseminated through its substance; and it is also broadly crusted on its exterior with chalk in hard combination with the flint. To assign a cause for the chalk which ignores the flint would be unworthy of science. If the chalk was formed at the bottom of the sea, the flint must have been formed there also. If there are specimens of flint which were not formed there, they will equally disprove the marine origin of the chalk in connection with them; and found even in their interior. I have carefully examined by the microscope some

chalk taken from the interior of a flint, and can find no vestige of foraminiferæ or minute shells of any kind. And I venture to suggest that, in extending to the whole mass of the chalk formation, a conclusion drawn from that small quantity of some favourable *marine* specimens[6] which could be passed under the small object-glass of a microscope, an enormous and unwarrantable assumption may have been made.

It is with facts we have to do as the basis of our reasoning; and, with all deference to the learned and approved Geologists, who have collected so many valuable facts, their *theories* are not invariable, but have often changed. Even now the Uniformitarian theory of Lyell, and the prevalent Glacial hypothesis, are being seriously invaded; towards which some rather convincing facts have been adduced by the Duke of Argyll. We may therefore without presumption claim the liberty of looking at facts with our own eyes.

Flints, as we have said, are found abundantly in parallel layers in the chalk cliffs; on the face of which they may be seen conspicuously, one superimposed above another; and where they have manifestly been deposited at successive intervals, one layer separated from another by a mass of interposed chalk. They are found also abundantly scattered on the surface in other quarters, and in

[6] Such appear to have been the specimens which Ehrenberg examined. So Humboldt says: "*The beds of chalk which contain two of those sauroid fishes and gigantic reptiles, and a whole extinct world of corals and mussels,* have been proved by Ehrenberg's beautiful discoveries to consist of microscopic Polythalamia, many of which still exist in our seas and in the middle latitudes of the North Sea and Baltic." Cosmos, vol. i., p. 278.

other manners. A prevailing form of the smaller flints is approximately spherical or ellipsoidal, but generally flattened, and not unfrequently somewhat indented, as if by falling, before being fully hardened, on another flint of the same form. Each usually bears a crust, like chalk combined with the hard silex of the flint; as if the interior particles of disseminated chalk had worked towards the surface, and formed a skin there, in like manner (to borrow the suggestion of one writer) as sandiver or glass gall separates from and swims upon glass during its vitrification; though sometimes the formation of this crust might be prevented by the too sudden hardening of the matter itself. In many cases the gelatinous silex, falling into soft chalk, might also absorb a portion of the chalk into combination with its exterior, thus forming a thicker crust. In other cases falling into the sea, it might be more rapidly cooled. The surface is granularly corrugated, like that of some Scotch pebbles which used to be reputed of igneous formation. Whether the granular corrugation has been produced in the process of cooling, by shrinking, so as to resemble the surface of a shrunken apple, we cannot say. But certainly the round form of these flints has not been acquired by rolling among shingle on the sea beach. Where this has occurred to them, as is often the case, it rubs off the corrugated surfaces, and presents them smooth and semi-polished; and the crust of flinty chalk which is on them demonstrates that their form has not been acquired by rolling and trituration in any manner.

Where the flints are of larger size, the spherical or ellipsoidal form could not equally be taken or preserved; but the rounded tendency still often

shows itself in compound and more or less tuberose shapes, the white chalky-flint crust being exhibited as on the others. Larger still, the flints are found in huge splashes of irregular shapes and masses; the forms in many cases having been determined by their fall into the sea, or, if on land by the place on to which they have come while soft, and by the stones among which they have run in a fluid or semi-fluid state, moulding themselves into the interstices in the manner shown in some specimens which I have for illustration. These portions had obviously not lighted upon the soft chalk, but run among hard stones. Some flints had also apparently on falling, rolled down in a soft state upon a bank of reddish marl, part of which they had enclosed and doubled over upon; while, at the same time, they exhibit portions of the purest soft white chalk, enclosed in another part of the same flint. Now if the flint had been formed under water, it is impossible that this could have occurred; because the white chalk and red soil or marl could not have lain in such proximity under the water, without the white chalk being stained.

These facts of themselves are at variance with the idea of the flint being of marine origin; and we shall find many others which are irreconcilable with that conjecture. Yet unquestionably many flints exhibit incontestable records either of the sea, or of the seashore, by the organic remains which they contain of various sorts of Echinites, impressions of shells, or imbedded corals, sponges, and objects of that nature. It may be observed concerning these, that the flint has not grown into these organic forms by gradual chemical substitution for the matter which it displaced; but has flowed into them and

also around them. For the flint Echinites, which, when separated from the matrix of the flint in which they have lain, may seem like mysterious organic growths, formed by chemical substitution of flint, present a very different account of themselves, when undetached from the mass in which they have been. The flint mass in a fluid or gelatinous state has flowed round and enfolded the shell, and has also penetrated into it, entering by a small orifice, so filling it and moulding itself there. But its formation is destitute of any organic process, or affinity for such. This may not be known to many of those who have only seen the specimens when detached, but specimens undetached can easily be produced in illustration.

As regards the fluidity of the Silex, we know that it might arise either from fusion by intense heat, or by aqueous solution. The question is, Which? And here we premise that it is not necessary nor even allowable to assume that the same method of fluid formation applies both to flint and chalcedony or quartz; nor yet that all petrifactions have been formed by the same process. They may have the material of silex in common, but they may and do differ in formation and in texture. At present we confine our attention to the flint in connection with the chalk.

Some specimens, as has been said, are of the sea-shore; and undoubtedly many occur from the sea itself, some containing corals which had transfixed them, while soft, and been broken off in their fall. But it does not follow that in these cases the flint owes it origin to the sea, or was formed under it. The contrary is attested not only by some of the facts already referred to, but still more by other facts

which speak distinctly of the land, and therefore point to some origin which will equally apply to both.

Now I am prepared to show many objects of the dry land in flint, which could not have been formed under water, and which appear to me unquestionable, especially when viewed in their combined evidence. These consist of portions of decayed tree roots in flint, with the bark in parts covering places where the wood had fallen away, and showing also the rotten forms of the decayed interior. Portions also of other and larger trees from the chalk district of Yorkshire, in a different condition, showing indications of the rings of growth near the bark, and in an example which can be produced the veining of the interior wood. Together with these there are portions of dry hollow stalks of cabbage or similar plants; also pods of beans, or other leguminous vegetables, all of flint; portions of nuts or almond shells, in flint or flinty chalk; fruits of the fig or pear; gourds, or other vegetable fruits, with the attachment clearly shown; roots of the turnip, or analogous vegetables; portions of others of these in which the interior had been wholly or almost wholly eaten out by worms, and had become filled with soil, while the entrance hole of the worm or insect is traceable; small bulbous roots; together with spreading and jointed roots, which might be something of the *amomus* tribe to which ginger belongs; and specimens of fungus, all of flint. I am prepared to submit specimens of these to careful inspection.

In chalk also objects may be occasionally found which are not marine; though, in those portions which were submerged under the sea, they will not of course be so much expected. I have found the wing of an insect in chalk, which showed that that

portion of chalk at least was not formed under the sea; I have also the distinct impression in chalk of a piece of wood. But these may be regarded as comparatively trifles, when we are informed that it is in the cretaceous period that the monotonous vegetation of the older style is replaced by the more beautiful and varied forms of our modern woods.

"In Europe," writes Dr. (now Sir J. William) Dawson, "in the lower part of the Upper Cretaceous of Bohemia, have been found some leaves which indicate the beginning of this change. These have been referred to Caesalpinias or Brasilettos, pod-bearing trees of India and tropical America, Aralias or Ginsengs, Magnolias, Laurels, an Ivy, and a peculiar and uncertain genus (Credneria.) With these are noble palms, both of the types with pinnate and palmate leaves, and trees allied to the Giant Sequoias of California, and to the Araucarian pines of the southern hemisphere. These ancient Cretaceous forests of Eastern Europe are compared by Saporta with those which now live in the warmer portions of China or in South America,—truly a marvellous change from the sombre and uniform vegetation by which they seem to have been immediately preceded. A still further development of modern vegetation takes place in the next or highest member of Cretaceous, the Maestricht beds (*Senonian*), where we find a crowd of modern types. On this great change, Count Saporta remarks with truth that there seem to have been periods of pause and of activity in the introduction of plants. The Jurassic period was one of inactivity; and a new and vigorous evolution, as he regards it, is introduced in the middle of the Cretaceous.

"This new and grand elevation of the vegetable

kingdom in the Cretaceous age was not local merely. In Moravia, in the Hartz, in Belgium and France, even in Greenland, the same great renewing of the face of the earth was in progress. In America it was proceeding on a grand scale, and seems to have set in earlier than in Europe. In the Dakota group of the West, one of the lower members of the Cretaceous, and covering a vast area, a rich angiospermous flora has been discovered by Hayden, and described by Lesquereux and Newberry, and beds of coal have been formed from its remains. In Vancouver's Island in British Columbia, Cretaceous coal-measures occur, comparable in value, and in the excellence of the fuel which they afford, with those of the true coal formation." [7]

For these facts, as stated, Dr. Sir William Dawson is responsible; but I cite them as bearing in the same direction with the evidence I personally produce. The chalk itself, strictly so called, forms indeed one of the most barren soils; and the chalk downs furnish little besides a bare pasturage for sheep; but the red marl which is associated with the Cretaceous and Flint formations, and which in America extensively takes the place of the pure chalk, affords root to shrubs and trees. Remains of peculiar birds also have been found in the Cretaceous formation,[8] and, it is said, even indications of monkeys;[9] and much more might be presented from familiar sources of information, all contributing to

[7] "The Chain of Life in Geological Time," by Sir J. W. Dawson, LL.D., F.R.S., F.S.S., &c., pp. 187, 188.

[8] Ibid., p. 173, and Trans. Geol. Soc., 2nd series, 4to, vol. vi., page 411. The bird in this last citation was thought to be of an unknown species, most like the Albatross.

[9] Milner's "Gallery of Nature," p. 641.

show that the chalk was not formed at the bottom of the sea, though much of it may once have lain there.

The general sterility of chalk by itself, as a soil, may, however, suggest the inquiry whether many of these remarkable specimens of vegetation may not largely have grown on a previous and different antediluvian soil, and have become covered up and buried with chalk-dust, as with a snow-storm, from causes which will suggest themselves in the course of our investigation. That a blighting curse had fallen upon the land more than 600 years before the deluge is not improbable, from the words of the father of Noah, in giving him that name,—words which may not refer to the general curse upon the ground from Adam's days, so many centuries back, but which seem more special:—"This same shall comfort us concerning our work and toil of our hands *because of the ground which the Lord hath cursed.*" Patriarchal patience, skill, and industry may have succeeded in restoring verdure and fruitfulness even on that disadvantageous soil. And after the flood we read the promise that there should thenceforth be no further repetition of the curse upon the ground (Gen. viii. 21); rather implying that there had previously been a repetition of it, and apparently not referring exclusively to the primeval curse (Gen. iii. 17—19), which even now seems not repealed.

But the question of the origin of the chalk is too closely connected with that of the flint to be unaffected by the facts produced and to be produced regarding the latter.

Flint is also found in flat, tabular form, abundant in the cliffs at Flamborough, and between Ramsgate

and Dover, and also occasionally in seams running down the cleavage of the chalk in the cliffs, varying in thickness, as stated, from an inch and a half to the thinness of Bristol board. It is plain from the latter case, that the chalk was not lying as soft mud at the bottom of the sea when the flint ran down its cleavage, but that the chalk, even if originally formed or deposited there, had been upheaved, and had dried and cracked, and then, after the formation of these fissures, the fluid matter of the flint had run into them. But this goes quite against the theory of the flint having been deposited from thermal waters while the chalk was lying in process of formation at the bottom of the sea.

A different account must be found of the origin of the chalk and flint formation, such as will be consistent with all these phenomena, and will afford a sufficient explanation, both of those which are of the land and of those which are marine, or of the shore,—an origin common to both, yet belonging to neither. That origin we shall prove to be meteoric. However startling this may seem to some, who have been accustomed to limit the admission of meteoric falls of stones to a few marked by certain characteristics, it is yet agreeable to a favourite theory generally accepted by both geologists and astronomers. It is allowable to refer to it briefly and summarily here, as calculated to meet any objection of this sort; at least to those by whom that theory is entertained.

It was a deduction of the great French astronomer, Laplace, from the relative times of revolution and rotation of the planets and their satellites, that probably at a very remote period the sun and all the bodies of the solar system had been one nebulous

mass of very attenuated matter; which receiving a motion of rotation, and acted upon by the mutual attraction of its particles, was drawn gradually inwards. That, in this process of rotation and contraction, rings of this attenuated substance parted from it, and were left behind; and that these rings, continuing their rotary movement, again contracted upon themselves, and in process of time parting asunder, conglomerated into globular forms, while still in a very diffused and attenuated state; that these now rotating more rapidly from their contracted bulk, in some cases threw off rings of their substance left behind in their revolution, which parting again, gathered into secondary globes, revolving round the primary from which they had been parted. That thus, by progressive contraction, were formed planetary globes revolving round the centre of the whole original attenuated and diffused mass; and again secondary globes revolving round the primaries, from whose yet unconsolidated substance they in their turn had been cut off and left behind. Thus by ring after ring, proceeding from the outer nebulous boundary towards the interior centre of the whole revolving matter, planet after planet was separated, and its satellites, gradually, in their turn. The interior planets would be later than the exterior, and the body of the sun latest of all in consolidation. The theory leans upon the fact that the rate of periodic revolution of each planet in its orbit is that which would correspond with the rate of rotation of the whole diffused mass when of a magnitude filling that planet's orbit; and that the rate of revolution of each satellite in its orbit is that which would correspond with the rate of rotation of its primary planet, if its diffused sub-

stance occupied the whole interior of that satellite's orbit; the longer radius of the rotating mass making the rotation slower, and the reduced and separated body having it quicker; just as a long pendulum swings more slowly than a short one.

This nebular theory—which is not at variance with St. Paul's inspired statement that "the things which are seen were not made of things which do appear"—has been extensively adopted as probable by modern astronomers and geologists; not that any one supposes that all matter is of a single nebulous element (for modern chemistry has, I believe, proved the existence of at least sixty-three different elements which do not admit of being resolved further), but only that all were as yet unseparated and unconsolidated. But be this as it may, the theory has been extensively accepted; and no doubt the Almighty Creator was able to bring order out of this chaos of impalpable elements. It is therefore worth noting two consequences which would necessarily follow from it.

First. In relation to the earth, the light of the nebulous mass, as it gradually contracted inward, must have been divided from the darkness of the outer space when the nebulous mass, in its contraction, passed within the orbit of the earth; and then first, in relation to the earth, began the alternation of light and darkness in the course of the earth's rotation on its axis. But two more stages in the contraction of the central nebulously diffused light must have taken place in the successive separation of the orbital rings of the planets Venus and Mercury, and in the consolidation of these planets, before the light was brilliantly condensed in the sun as central luminary, and from him reflected in the

moon. This is singularly in accord with the Scriptural record of the Creation, which puts the dividing of the light from the darkness on the first day, but interposes two clear stages of the work before the forming of the sun and moon, and setting them in the heavens as the two great luminaries, the placing of these being assigned to the fourth day of the Creator's work—days here being, of course, GOD'S WORKING DAYS, not man's working days of his brief *memorial*[1] week. This consequence should make some sceptical men of science pause in their sneers at the revealed record of the Creation and consider.

Secondly. It follows from this theory that everything which is upon the earth has ultimately come to it *ab extra*, by gradual condensation and attraction of materials from the diffused nebular expanse towards a centre; though, of course, liable to many changes and new combinations afterwards when upon earth, of which geology traces the abundant evidences. This consequence will be found of much importance in regard to some geological facts, and some too hasty assumptions; and specially it follows that it is in full consonance with science that the chalk and flint formation may have come *ab extra*, that is, from a meteoric source; and that it is an unscientific objection to say that no meteoric substances have fallen, except such as have been analogous to those

[1] The fourth commandment notably commences with the word "Remember," marking the simple memorial character of man's week, and that it was an institution *prior* to the law given upon Mount Sinai. It is obvious that man's *first* day upon earth was upon God's *seventh* day, for he was created at the end of the sixth. How, then, can any maintain that the Creator's week, as recorded, is meant to be understood as the same in continuity with man's recurring memorial of it? The Creator's day of rest has not surely been of the same measure with man's memorial Sabbaths.

whose fall in recent times has been witnessed and universally recognized.

It is necessary, however, to point out that some unwarranted conclusions have been drawn by men of science from this nebular theory. For it has been supposed that the heat of the nebulous materials was such as would now suffice to sublimate all things into vapour; that, when this vapour contracted into the planetary form, it assumed the condition of an incandescent fluid globe; and Sir William Thomson has expended time and pains in calculating how many millions of years it must have taken for the earth to cool down to its present state, from that condition of fiery fluid incandescence—a calculation which may rather serve to shake the credit of that assumed condition of the earth. It cannot be proved that either twenty millions or four hundred millions of years ago,[2] there was more heat, more electricity, or more light in the materials of the solar system than there is now. "There are," says Sir Charles Lyell,[3] "no positive proofs of a secular decrease of internal heat accompanied by contraction. On the contrary, Laplace has shown, by reference to astronomical observations made in the time of Hipparchus, that in the last two thousand years at least there has been no sensible contraction of the globe by cooling; for, had this been the case even to an extremely small amount, the day would have been shortened; whereas its length has certainly not diminished during that period by $\frac{1}{300}$th part of

[2] These are the *minimum* and *maximum* limits assigned by Sir William Thomson for the time necessary for the earth to cool down to its present temperature from fluid incandescence. Trans. Royal Society of Edin., xxiii. 157.

[3] "Principles of Geology," vol. i. p. 304.

a second." Nor is it analogous to the course of nature that, from the nebulous state, the materials should contract into one vast fluid globe of the earth's dimensions, at an intense heat, and then begin slowly to cool and solidify. The vapours of the sky do not form themselves into an immense globe at the temperature of boiling water, but into innumerable minute dewy particles; which again draw together into drops, and fall in cool and fertilizing showers. What has sound science to say against a similar process in the condensation of the earth's materials from the nebulous state? Do not the falls of meteoric stones furnish a plain illustration of the contraction first into smaller portions, thence gathering into larger bodies; and these by attraction grouping into larger, and so conglomerating together into spherical masses? The ancients had a clearer perception of the process of some such concentration of materials from illimitable space; and a fragmentary statement of the theory of Leucippus the Eleatic, the reputed founder of the atomic philosophy (who flourished about 428 years before the Christian era, and belonged to a branch of the Italic school of Pythagoras), presents a juster tradition of the consequences deducible from a philosophic doctrine akin to the nebular theory. Hesychius of Miletus, in a fragment which has come down to us, thus states the matter: "Leucippus maintained that the earth moves in revolution upon its axis, and that its form is tympanoid (meaning probably protuberant). He also was the first who maintained that atoms were the ultimate principles. He says that the universe is boundless, and its space partly filled and partly void; that there are boundless elements, and that innumerable worlds are formed of these, and

are resolved into these. Moreover that the worlds are formed in this way. That many bodies of all sorts, segregated from the infinite expanse, are carried into void space, and, when collected together, form one vortex of rotation, in which, by colliding while circling round together in all their multifariousness, they become separated and assorted like to like. But when, from their multitude, they could no longer be carried round in equipoise, the finer and lighter go off into the outer space as if they were sifted out; the rest remain together, and, becoming entangled, run together with one another, and form, first, a sort of spherical arrangement. That this spherical shape, like the envelope of an embryo world,[4] including in itself all sorts of bodies, serves as a substratum; and, having its motion rotatory in consequence of the counter momentum at its centre, the superficial skin or envelope (so to speak) becomes stretched and enlarged, as contiguous bodies, impinging upon the vortex of its revolution, flow together to it. That the earth was formed in this way, those things remaining with it which were carried into the midst; and that, again, the spherical surface itself, as it were the enclosing skin or membrane [in modern phrase, *crust*], is thus enlarged by the continual acquisition of bodies from without, which it acquires by impinging on them in the range of its revolution." [5]

[4] Οἷον ὑμένα. Alii ὑμέναϛ vocant membranas quibus fœtus includuntur.—*Scapula.* The meaning of the passage has been liable to be much misapprehended from neglecting the force of the metaphor.

[5] Diog. Laert. ix. 30—33. Muelleri Fragm. Historic. Græc. iv. 168, 41. The Greek of the above fragment of Leucippus is as follows :—

Λεύκιππος ὁ Ἐλεάτης ἔλεγεν . . . . . τὴν γὴν ὀχεῖσθαι περὶ τὸ

I have endeavoured to render the passage accurately to the meaning. If we make some allowance for the imperfection of a statement which we have only at second hand, it seems to me to have that in

μέσον δινουμένην· σχῆμά τε αὐτῆς τυμπανοειδὲς εἶναι. Πρῶτός τε ἀτόμους ἀρχὰς ὑπεστήσατο. Τὸ πᾶν ἄπειρόν φησι, τούτου δὲ τὸ μὲν πλῆρες εἶναι, τὸ δὲ κενόν. Καὶ στοιχεῖά φησι κόσμους τε [ἐκ τούτων] ἀπείρους εἶναι, καὶ διαλύεσθαι εἰς ταῦτα. Γίνεσθαι δὲ τοὺς κόσμους οὕτως· Φέρεσθαι κατ' ἀπονομὴν ἐκ τῆς ἀπείρου πολλὰ σώματα παντοῖα τοῖς σχήμασιν εἰς μέγα κενὸν, ἅπερ ἀθροισθέντα μίαν ἀπεργάζεσθαι δίνην, καθ' ἣν προσκρούοντα καὶ παντοδαπῶς κυκλούμενα διακρίνεσθαι χωρὶς τὰ ὅμοια πρὸς τὰ ὅμοια· ἰσορρόπων δὲ διὰ τὸ πλῆθος μηκέτι δυναμένων περιφέρεσθαι, τὰ μὲν λεπτὰ χωρεῖν εἰς τὸ ἔξω κενὸν, ὥσπερ διαττόμενα· Τὰ δὲ λοιπὰ συμμένειν, καὶ περιπλεκόμενα συγκατατρέχειν ἀλλήλοις καὶ ποιεῖν πρῶτόν τι σύστημα σφαιροειδές. Τοῦτο δὲ οἷον ὑμένα ὑφίστασθαι, περιέχοντα ἐν ἑαυτῷ παντοῖα σώματα, ὧν κατὰ τὴν τοῦ μέσου ἀντέρεισιν περιδινουμένων, λεπτὸν γίνεσθαι τὸν πέριξ ὑμένα, συῤῥεόντων ἀεὶ τῶν συνεχῶν κατ' ἐπίψαυσιν τῆς δίνης. Καὶ οὕτω γενέσθαι τὴν γῆν, συμμενόντων τῶν ἐνεχθέντων ἐπὶ τὸ μέσον. Αὐτόν τε πάλιν τὸν περιέχοντα οἷον ὑμενα αὔξεσθαι, κατὰ τὴν ἐπικράτησιν τῶν ἔξωθεν σωμάτων· δίνῃ τε φερόμενον αὐτὸν ὧν ἂν ἐπιψαύσῃ, ταῦτα ἐπικτᾶσθαι.

That this theory originated from the observation of meteoric star-showers, and the fall of meteoric stones, appears from his further inference that the fire of the stars was caught by rapid motion. Astronomically he held that, of the heavenly bodies, the moon was nearest to the earth, and moved in a smaller circle; while the orbit of the sun [in his annual apparent course] was much the greatest: that the occasional occurrence of eclipses was owing to the inclination of the earth's axis [to which they have a relation, as in fact they only happen near the nodes of the two inclined orbits], and that the greater frequency of lunar eclipses was owing to the moon's orbit being so much less [the nearer distance, of course, inferring also her smaller size.] Some allowance should also be made for the imperfection of Hesychius's brief statement.

The theory of Leucippus has been misunderstood, and so misrepresented, by Sir George Cornwall Lewis, "Astronomy of the Ancients," p. 136. The cycle of eclipses was well known to the Chaldeans long before the time of Leucippus; and by it Thales of Miletus predicted the great solar eclipse of May 28th, B.C. 585.

it, from which the modern scientific adherents of the nebular theory may take a sounder lesson of the rational consequences of such a theory, than modern science has attained to. Astronomers have thought that the rings of Saturn may illustrate Laplace's idea of the rings left behind in the consolidation of the planet, of which a portion had already parted and formed into satellites, and the remainder may yet in process of time part into other nearer satellites. But might they not equally see an illustration of the fact that the tendency is first to contract into smaller bodies, these gradually running into larger, and these larger at length gathering into a planet, in the fact of those two hundred small planetary bodies called the "asteroids," coursing round the sun between the orbits of Mars and Jupiter, and which occupy in the solar system approximately the position where, according to Bode's law of proportionate distances, a planet might be expected to be, and which, in the gradual course of ages, may eventually be drawn together to form one planet? Might not this as well be taken to illustrate the theory of Leucippus, as Saturn's rings to illustrate that of Laplace? Appropriately to the thought, meteoric stones are spoken of by the same name, as "the smallest of all asteroids;" and, speaking of the different meteoric streams of small cosmical bodies, Baron Humboldt remarks, that "the smaller planets between Mars and Jupiter present us, if we except Pallas, with an analogous relation in their constantly intersecting orbits."

But we have to deal at present only with the chalk and flint formation; and not with theory but with facts. I affirm, then, that the facts demonstrate that this formation is not of marine origin, nor of land origin; but from a source equally

available to land and sea, and therefore necessarily meteoric: for there is no other alternative. Let us now consider the evidence of the facts in relation to this source.

It is clear from the flint having occasionally flowed among stones, and moulded itself to their interstices, that it was in a fluid condition, not improbably molten. It may be objected that flint is one of the substances most difficult to fuse, requiring the heat of the oxy-hydrogen blowpipe for that purpose; but there is power more than sufficient in the laboratory of nature for that intensity of heat, whether by the element of the lightning or otherwise. Geologists assume that all the substances upon the earth were once in a state of incandescent fusion. They who think this, are not in a position to object. And it does not necessarily appear that the flint when previously in combination with some other substance, from which it was separated and precipitated, required so intense a heat for fusion, as now when it has hardened in its separate state. I find it stated, moreover,[6] that by Mr. Parker's large burning-glass, flint of the weight of ten grains was fused in half a minute, and carnelian in a minute and a quarter. Now, Sir Humphry Davy calculated that the heat which an aërolite extricated from the atmosphere by its rapid motion, exceeded 30,000° of Fahrenheit, a heat more intense than that of the fiercest artificial furnace. And I understand that the researches of Professor Sir William Thomson and Mr. Joule furnish data which would, in the case of a velocity of 39 miles a second, give the temperature ten times higher than this calculation of Sir Hum-

[6] Encycl. Brit.

phry Davy. It is known, in the case of acknowledged meteorolites, that they have fallen very hot, and that they bear a film on the surface from the sudden action of intense heat. Therefore a molten condition of the flint is sufficiently consistent with a meteoric source. The smaller flints very frequently, if not generally, present a spherical or ellipsoidal form somewhat flattened. The spherical form would naturally be assumed by a small fluid falling body in free space, as in the case of raindrops and hailstones; or, in the case of more rapid motion, the form would become elongated to the ellipsoidal. And the flattened condition of many flints often indented with the mark of another spherical or ellipsoidal body, indicates their having fallen, in a not fully hardened state, upon other similar stones. That these small flints might rapidly lose their heat in their descent, and pass from the fluid to the solid state from meteoric causes, may be seen in the fall of ordinary hailstones, which are simply frozen water, formed often in the hottest weather. That each of these small flints was formed separately, and not by fracture followed by rolling and trituration, appears distinctly from its crust. On the other hand, large splashes of fluid flint, like bucketsful, could not be expected to assume or retain in falling a similar spherical form, but only some approximate tendency in the rounding of their parts, and would in falling into water or upon irregular surfaces be greatly modified.

Not improbably the chalk and flint may be separated constituents of one composite substance analogous to felspar, which by the action of intense heat was disintegrated, its silica molten, and part

of the other ingredients blown into incandescent chalk dust. This simultaneous origin appears to be indicated by the grains of white chalk seen under the microscope to be disseminated in the dark flint; which have, in its fluid state, worked towards the surface, and formed there a skin of flinty chalk as above suggested. That white crust may also, in many cases, have been increased from the molten silica having incorporated with itself externally a portion of the soft chalk into which it fell; with which I have learned from a practical artist in glass, that it would have a tendency to combine. The same appears also from portions of the purest soft white chalk being found imbedded and completely enclosed in the substance of many of the larger flints, which, at the same time, bear evidence of having fallen not upon white chalk, but upon reddish marl. In other cases the molten flint, falling upon a hard flat surface, has spread out in tabular masses, or run into cracks and fissures of the cliffs. In many cases also their fall must have been into the sea, which covers two-thirds of the globe.

A statement which was made some years ago by an eye-witness, at Fawley, near Southampton, Hants, of the fall of two meteors, one of which was found to be a flint meteorolite, appeared to me to favour this view. One of the meteors leaving behind it a long train of sparks, after bursting into an intense flame, left a luminous vapour or cloud, carried gently by the wind for some time, and assuming various shapes. A cloud of incandescent chalk dust might be thus carried by the wind some distance, and while the heavier flint fell nearer, the chalk might be, and in point of fact often has been, carried further, and separately deposited on the

lee of a projecting hill-ridge. It might also be expected to assume, when deposited on the land, the gentle undulations as of drifted snow; as is much the case in the downs of chalky regions, which have that gently undulating character. I may mention here also the ancient record of the fall of a meteorolite witnessed by one Eusebius, which is preserved to us by Photius, Patriarch of Constantinople, in a fragment of Damascius. It was seen to come rushing down suddenly in a globe of fire, and was immediately after picked up, and from the description given of it—as globular, measuring a span in its mean diameter, whitish in colour, but showing purplish occasionally—it appears to have been a flint.[7] Iron also is well known to have fallen in meteoric masses; and iron pyrites often occurs in the chalk in peculiar balls of a concentrically radiated fibrous construction, which would seem to require free space for their formation by the electric and molecular attraction of particles.[8] Baron

[7] Σφαίραν δὲ πυρὸς ὑψώθεν καταθοροῦσαν ἐξαίφνης ἰδεῖν· . . . . αὐτὸν δὲ ἐπὶ τὴν σφαίραν δραμεῖν ἤδη τοῦ πυρὸς ἀποσβεννυμένου, καὶ καταλαβεῖν αὐτὴν οὖσαν τὴν βαίτυλον. Σφαίρα μὲν ἀκριβὴς ἐτύγχανεν ὢν ὑπόλευκος δὲ χρῶμα, σπιθαμαία δὲ τὴν διάμετρον κατὰ μέγεθος, ἀλλ' ἐνίοτε μείζων ἐγένετο καὶ ἐλάττων, καὶ πορφυροειδὴς ἄλλοτε. This stone, as well as some others of the same nature, was treated with superstitious veneration and consulted as an oracle, abetted by priestly fraud and fables. "Photii Myriobiblon," pp. 1062, 1063. Ed. fol. Genevæ, 1612. Bochart. Phaleg. c. 707.

[8] There are occasionally vegetable remains and even small animal bones found converted into pyrites, as if by aqueous infiltration. Branches of trees so converted into sulphide of iron are found occasionally in a bank with a sandy stratum, beside the landslip, or Warren, near Folkestone, or washed up by the sea there. But these do not present a parallel case. It seems hard to conceive how the aggregation of detached balls of crystallized fibres radiating to all sides from a common centre, could be formed without inequality or compression, otherwise than in free space ;

Humboldt mentions in his "Cosmos" the ancient record of a fall of meteoric gold. He also mentions an earthy aërolite of Alais in the Department du Gard, which broke up in water, and those of Jonzac and Juvenas, which contained no metallic iron but a mixture of oryctognostically distinct crystalline components, which had led mineralogists to separate these cosmical masses into two classes, namely, those containing nickeliferous meteoric iron, and those consisting of fine or coarsely granular meteoric dust.[9] Latterly meteorites consisting of carbon have been found; and of these there are some specimens in the British Museum, presented by Sir John W. F. Herschel in 1845, which fell at Bockeveldt, Cape of Good Hope, on the 13th of October, 1838, and others by the same and Mr. Maclear, the Astronomer-Royal at the Cape, and by Mr. Charlesworth in 1839; and from Montauban in the Department of the Tarn and Garonne in France, on the 14th of May, 1864. There is also in the Museum at Dover a mass of carbon which was found in the chalk in making the Sibertswold tunnel, which I do not doubt is meteoric. It is of a very cindery and friable nature. Many meteors leave long trains of burning matter, like sparks, behind them. Is it improbable that these are carbon? These things are all in harmony with the fact that every substance now upon the globe must have come to it from exterior space; in other words, must be from a meteoric source, according to the accepted nebular theory of geologists and astronomers, though the former seem not fully to have adverted to the consequences of

or how otherwise such balls should be found in the heart of a cliff of pure white chalk.

[9] "Cosmos," vol. i. pp. 118—120. Ed. Bohn, 1849.

this circumstance. Professor Sir William Thomson, however, when President of the British Association in its meeting at Edinburgh in 1871, went so far as to suggest that even seeds of life might have come from a meteoric source extraneous to this earth.

But apart from theories, we are dealing with the evidence of facts. The flint has in very numerous cases moulded itself into organic forms, partly of the sea, partly of the land; and this has manifestly not been from any special aptitude of the flint for organic attraction or substitution. How then are these forms to be accounted for?

Now in some cases the answer is plainly furnished by the facts themselves. The galerites and various other echinites are found imbedded in circumfluent flint, which has found an entrance into the shell by an orifice and has filled it, thus moulding itself into the form. So also with lobster-claws, and similar objects of the sea-shore. In regard to the vegetable forms the case requires a little more careful consideration; but they also will be found to give of themselves a reasonable explanation of their origin. They consist of decayed and dried tree-roots or broken branches; or of vegetable roots or fruits which had been lying for the most part covered by the soil with a part protruding. The molten flint, falling as liquid fire upon the ground, has apparently burned off the protruding part, and has then eaten its burning way into the tinder of the rotten tree-root wherever it was not bounded by the incombustible soil in which it lay. And the same with old dry vegetables, often eaten out by worms and filled with soil, or pods and fruits which have fallen and become covered with soil, leaving only a small part protruding sufficient for the fiery fluid of the

flint to lay hold of and find an entrance by. Thus, burning out the vegetable substance the flint has taken its place; and the soil which surrounded the vegetable being incombustible has limited its further progress, and served as a perfect mould when the combustible material has been consumed; just as a mould is formed for the casting of iron by a wooden shape constructed of the exact intended form of the iron, and placed in sand prepared for receiving its impression, then removed that the fluid metal may run into the place so vacated. In the case of these specimens, it was removed by being consumed in the way specified, and the mould thus formed was occupied in the same manner. The burning out of the dry wood or vegetable in many cases disengaged sufficient gases to bulge out and blister the bark before escaping through the porous soil; and this appears in many of the specimens. It may be remarked in passing that this blistering is adverse to the idea of any watery process of formation, such as infiltration, and is almost of itself demonstrative of the operation of fire.

That molten meteoric matter has been known to fall, and to flow as liquid fire along the ground, appears in the record of that ever-memorable hail-storm in Egypt (Exod. ix. 23—25), in which there was "fire mingled with the hail," and "the fire ran along the ground." This does not and cannot refer to lightning, which does not run along the ground; and the word translated "ran" does not mean "flashed," but may equally be rendered "flowed," being applied to the running of rivers. The fire also is there spoken of as "rain."

As a consequence of this mode of formation of the flint casts of vegetables, fruits, and portions of tree-

roots, it may be observed that the flint exhibits only the external cast, and in the interior there is the grain of the flint without any indication of the fibre of wood, such as might have been expected if the specimen had been formed by infiltration from water, or matter of equal fluidity. The same may be said generally of the remarkable specimens of silex moulded into portions of trees which occur in what is known as "the petrified forest of Cairo," which has, I incline to think, been formed in the same manner; and which may thus afford a remarkable standing witness to the memorable plague of the hail and the "continuous rain of fire"[1] which ran or flowed along the ground.

By the kindness of my friend, Mr. Tod, of Alexandria, I have been furnished with interesting specimens of these extraordinary remains; and the sand and pebbles which have lain contiguous to them appear to indicate the fact of the formation having been made by the action of fire, from the manner in which they are occasionally *welded* together; just as the shingle of the sea-beach has been welded into hard plum-pudding stone by the irruption of igneous

[1] Exod. ix. 23, 24. אֵשׁ מִתְלַקַּחַת; Gesen., "*continuous fire.*" The Authorized English Version renders it "fire *mingled with* the hail." But in Ezek. i. 4, the same word occurring cannot *there* mean "mingled," but rather "*continuous*" (English Authorized and Revised Versions, "*enfolding itself*"). The "*fire*" is called "*rain*," Exod. ix. 34; for it is not *aqueous* rain which is recorded to have thus accompanied the hail, but "fire;" even as it "*rained*" fire and brimstone upon Sodom (Gen. xix. 24). The expression is the same in the two cases in the Hebrew original, just as it is in the English. In Psalm cv. 25, accordingly, the fire is spoken of as a shower; where the literal order and rendering of the Hebrew is, "He gave for their showers, hail, fire, flames in their land;" with which the Septuagint Version is in accordance. And in the book of Wisdom, ch. xvi. 16—22, it is spoken of as having caused much

dikes of trap; as may be seen at Port-na-Cross, on the coast of Ayrshire, near West Kilbride, and at other places.

The more delicate marking of the grain of wood on the surface of these Cairo specimens is to be ascribed to the finer grain of the sand in which the wood had lain, and to the greater fluidity of the molten silex which fell and ran along the ground. This may be illustrated by the analogy of the case of flowing lava, of which I take a statement from De la Beche.[2] "The following," says he, "is a summary from various authorities of the heat and appearance of a lava current. Lava, when observed as near as possible to the point from whence it issues, is, for the most part, a semifluid mass of the consistency of honey, *but sometimes so liquid as to penetrate the fibre of wood.* It soon cools externally, and therefore exhibits a rough unequal surface; but as it is a bad conductor of heat, the internal mass remains liquid long after the portion exposed to the air has become solidified.'"

To these arguments of a meteoric origin of the chalk and flint formation I may add the evidence furnished by some specimens of yet a different kind. The spherical form, as has been remarked, may become ellipsoidal from more rapid motion in space; and in some cases the ellipsoidal form has become very remarkably elongated, as if by violent projection, like an arrowy missile. The psalmist perhaps alludes to these in connection with a memorable meteoric storm—probably that which

destruction by burning; showing how it was traditionally regarded as a flaming downpour of fire, ξένοις ὑετοῖς, "a new kind of rain, and hail, and inexorable showers."

[2] "Manual of Geology," pp. 107, 108.

occurred in the days of Joshua—"He shot out his arrows and scattered them,—hailstones and coals of fire." These arrowy ellipsoids, coming down not always in perfectly parallel lines, seem occasionally to have impinged on one another and cohered together in a slightly angular manner. Of this I present a specimen. And in one instance I have found a specimen which distinctly tells its own tale of its meteoric source and descent; for it consists of one of these arrowy ellipsoids of flint, which has come down upon two thin layers of tabular flint, both of which had been at the time not perfectly hardened, the upper one softer, the other more tough. Through the upper of these two tabular pieces the descending arrowy flint has quite penetrated, and dinted out the lower, but has been partly forced up again by the toughness and elasticity of the lower, and has drawn up along with it the edges of the upper where it had penetrated. It has had a longitudinal slice cut off at the same time, apparently by lightning.

I have carefully used the microscope for the testing of my conclusions in minute particulars; but the main facts which are rested on are patent to the naked eye, and are too manifest to need, or to be affected by, any process of examination by thin slices microscopically scrutinized on Dr. Bowerbank's method. The microscope, however, renders very distinct the white grains of chalk disseminated in the dark flint, and confirms the general absence of the woody fibre in the interior of specimens from the Petrified Forest of Cairo, as well as in that of the flint specimens of tree-roots. In the former, indeed, it is not quite so absolutely so, the fiery "rain"[3] having been probably in a more perfectly

[3] Exod. ix. 34, מָטָר (comp. Gen. xix. 24, הַמְּטִיר). Fire, and

liquid state, and capable in some degree of penetrating and taking some partial impression from the fibre of the wood which it consumed, as De la Beche says is also the case with some lavas.

We have already noted, but it may not be amiss to repeat here, two particulars which seem to bear upon the question of the igneous or aqueous origin of the flint; namely, first, the manifest blistering of the exterior bark of the flint specimens of tree-roots by the escape of the gases in burning, which would not have occurred in aqueous infiltration; and secondly, the welding together of the contiguous sand and pebbles in the instance of the specimen from the Petrified Forest of Cairo. It may be added that in some cases the chalk into which the flint has fallen has been partially crystallized, apparently by contact with the burning heat of the flint. A practical geologist has even lately pointed out to me ironstone which had apparently been partially fused by the burning heat of flint which had fallen into it.

In the preceding observations I have not touched upon the subject of chalcedony, which is not connected with flint except as being occasionally found lining the interior of hollow nodules. If it be of different formation, as it also differs in structure and qualities, we are not now concerned with it. It is found in rocks of igneous origin; sometimes in stalactitic forms, sometimes reniform or botryoidal; but I am not aware that its stalactites show the concentric rings which are exhibited by those that are formed by aqueous filtration, as in the case of

not *aqueous* rain, had been spoken of as accompanying the hail; and so in Psalm cv. 32, the literal rendering and order of the Hebrew there being, "He gave *for their showers* hail, fire, flames in their land." So also the Septuagint in that place.

calcareous stalactites, which indicate their progressive manner of formation. Whether the two other special forms of chalcedony have had anything to do with the ebullitions of the substance in a state of incandescent semi-fluidity, may still be open to inquiry. Agates again, which consist largely of concentric chalcedonic bands, are found to have been abundantly formed in rocks of igneous origin, though they have of late been a good deal speculated on as of aqueous formation.[4] They, also, are foreign to the question of the origin of the flint and chalk formation: and quartz, in like manner, has been excluded from the present inquiry. But a few particulars may here be added as to some siliceous petrifactions which, though long known, seem to require further investigation and illustration. The late Mr. Evan Hopkins[5] tells us that in Peru and Chili pieces of wood that for years had been left standing in old mines have been found partially converted into siliceous fossils, and others again covered only with calcareous spar, metallic silver, grey and red silver ores, and fine crystals of iron-pyrites, by solutions from metalliferous rocks. "Siliceous springs," he writes, "are equally abun-

[4] Some very interesting information on the subject of aqueous silica will be found in the Cantor Lectures of Professor Barff, on Silica and Silicates, published in the Journal of the Society of Arts. See particularly Lect. ii., in the Journal of August 16th, 1872. The lectures have since been published separately. A curious interchangeable action of silicic acid and carbonic acid was experimentally illustrated by him, and is alluded to by him as follows: "You see here the silicic acid has been able to turn out the carbonic acid from the carbonate of potash at a high temperature; and before we part, I will show you the reverse, that, in the cold, carbonic acid is able to turn out silicic acid."

[5] "On the Connection of Geology and Terrestrial Magnetism," by Evan Hopkins, C.E., F.G.S., 2nd Edit. 1851, pp. 39, 81.

dant in all the granitic and porphyritic formations of the world. Large trunks of trees, and timber in old mines which have been long under water, have been found silicified in a comparatively short period. Even vegetation contains a proportion of silica taken up by the roots, and crystals have been found in the cells, and often large ones in the bamboo. There are (he adds) immense siliceous and calcareous stumps, in their natural growing position, in Chili, Veraguas, in Australia and Egypt; showing most distinctly that the trees were silicified when in the act of growing, by an excess of silica and lime getting into the soil. The upper part having decayed, the whole forests appear to have been snapped off by the winds nearly at the same time, the brittle character of the stumps having caused them to break off like glass horizontally a few feet in height." What my reader may think of the credibility of this theory of the entire silicification of the trunks of trees while actually growing, I know not. To what extent it may be possible for siliceous infiltration to go on, being drawn up with the sap during the life of the tree, may admit of inquiry or perhaps even experiment; but it seems to me improbable that it could proceed in *living* trees to the total silicification of the trunk, as is implied in the general theory thus propounded by Mr. Hopkins. Perhaps a process begun to a moderate extent during vegetable life, might be continued and completed by attraction of affinity afterwards when the tree was dead. It is not for me to conjecture.

In our own Isle of Portland there is a remarkable stratum of soil to be seen in the quarries, containing stems of prostrate silicified trees, and also petrified tree-stumps erect and rooted in the soil. I have

lately seen one large trunk, now lying in one of the quarries, which is twenty-six feet in length, ten feet in girth, and three feet eight inches in its greatest diameter, being the largest specimen yet found there, and well worthy of a place among geological specimens in the magnificent Museum of Natural History at South Kensington. Attention was drawn to these singular remains half a century ago by Mr. Webster, then Secretary of the Geological Society,[6] and by Professor Buckland and Mr. De la Beche.[7] But these petrifactions, though siliceous, are not of flint: and this is important to be observed in reference to the subject of this paper, if there be a probability of their aqueous origin. The trees found at Portland are said by these authorities to be generally of the dicotyledonous class, or coniferous, from one to two feet in diameter, some three feet: one much larger has been mentioned above. "The woody part," says Mr. Webster, "is siliceous, and the longitudinal vessels are filled by and surrounded with radiated quartz: numerous veins of chalcedony also pass through these stems, but always following the direction of the concentric and radial structure." I should not say that this description exactly fits the specimens which I have, or which I have seen; but the fibre of the wood in the largest tree appears to be perfectly infiltrated, and converted into silex through and through, when examined with the microscope in a portion taken from the centre of the base or root. In another dissimilar case of a standing stump, I observed it converted into minute crystals. In

[6] Trans. Geol. Soc., 2nd series, vol. ii. p. 38.

[7] Trans. Geol. Soc., 2nd series, vol iv. part 1, pp. 14, 15; and Buckland's Bridgwater Treatise, vol. i. p. 498, *note*, and vol. ii., plates 56, 61.

the ravines communicating with the Dneister, near Moghilef, we are informed that there is found siliceous wood in considerable quantity, which much resembles that of Portland; and also that siliceous wood resembling that of the palm-tree has been found near Tomaspool.[8] These cases, it will be seen, are not analogous to the specimens from the flint and chalk formation, nor even to those of Cairo.

I have also received some siliceous specimens from Colorado and Montana through the kindness of friends; in one of which, from the petrified Forest of Colorado,[9] the converted wood-fibre is perfect throughout even to the minutest microscopic filament. The Colorado springs are strongly impregnated with soda, which contributes to the aqueous solution of silex, and there are also hot springs. In some other cases the specimens present only the *cast* of the bark, or of the fragment of wood, with an interior of stone destitute of fibre.

[8] The Hon. Mr. Strangways on the Geology of Russia (1821). Trans. of Geol. Soc., vol. i. p. 39, *note*.

[9] The following extract gives some interesting particulars:—"A Petrified Forest.—The petrified forest near Corizo, on the Little Colorado, is a sight which travellers should not miss. The visitor to the forest begins to see the signs of petrifaction hours before he reaches the wonder. Here and there, at almost every step in the road, small pieces of detached limbs and larger stumps of trees may be seen almost hidden in the white sand. The road at a distance of ten miles from Corizo enters an immense basin, the slope being nearly a semicircle, and this is enclosed by the high banks of shale and white clay. The petrified stumps, limbs, and, in fact, whole trees, lie about on all sides; the action of the waters for hundreds of years has gradually washed away the high hills round about, and the trees that once covered the high table-lands now lie in the valley beneath. Immense trunks, some of which measure over five feet in diameter, are broken and scattered over a surface of 300 acres."—*Iron*.

It may, in passing, be mentioned that in tree branches converted, without doubt by aqueous infiltration, into sulphuret of iron, which are found in a sandy bank beside the landslip near Folkestone, and occasionally washed up by the sea there, the interior fibre is microscopically perfect. I have also a similar specimen said to be from a deep cutting near Dover; and many small specimens of the same description are gathered at Gravesend.

But I do not go into that portion of the subject, beyond pointing out that it is not to be mixed up with the question of the origin of the flint and chalk formation; nor ought it even to be assumed that all chalcedonic and quartzose formations admit of the same explanation with one another, or are necessarily *all* aqueous in their formation if some may prove to be so.

In conclusion I may briefly indicate two inferences, which perhaps may already have spontaneously suggested themselves.

First, considering the vast extent of the chalk and flint formation, it is manifest that had it all fallen upon the earth at one time, it might have materially affected the earth's balance. But, coming by degrees at successive periods, the balance might adjust itself by a flow of the waters of the sea to the opposite part of the globe where the weight had to be counterbalanced. This receding of the waters would have the effect of a rise of the chalk above the level of the sea, such as has actually occurred; or, which is equivalent, a subsidence of the sea-level relatively to the chalk. On the other hand, the gradual accumulation of a vast mass of compensating waters at the opposite side of the world, might, by its superincumbent weight, at last break down the underlying

strata there, crushing up the deep cavernous structure, and so causing the sudden sinking of a continent. That a former continent has actually sunk to untold depths in the Pacific Ocean is generally thought. Such an event, by shifting the weight there nearer to the earth's central nucleus, would, on the principle of the steelyard, alter the balance, and under certain conditions, would demonstrably produce a sudden change of the earth's axis; of the actual occurrence of which there is geological and other evidence, Jamaica and Vienna having had at one time nearly the same climate,[1] and therefore, we may conclude, approximately the same parallel of latitude, though now differing about thirty degrees.

I have said that under certain circumstances a change of axis would demonstrably result. It is true that the astronomers generally, with Sir Isaac Newton and Laplace, have thought a change of the earth's axis impossible, or so improbable that the supposition could not be entertained; but this they have done in consequence of taking into account the whole vast mass and weight of the earth as the obstacle. But the mathematician Bond, and after him Halley, the Astronomer-Royal of his day, who was also the practical founder of the science of Terrestrial Magnetism, deduced from the facts of magnetism that there is a nucleus of the earth now revolving differently from the main mass of the earth; and though men of science for a time disparaged this opinion, yet the late Sir Edward Sabine, who was preeminent in this department of science, said in his presidential address to the Royal Society, read May, 1864,[2] that he thought Halley's

[1] Lyell, Prin. of Geol., 10th Ed., vol. ii. p. 201.

[2] Phil. Trans., p. 242.

Terrella had not received the attention it deserved. Now on this ground manifestly there comes for consideration an entirely altered state of the case. For such a nucleus, while accounting for the fact of the secular revolution of the magnetic pole round the earth's geographical pole, would have the effect of a ball-and-socket joint, round which, the earth's balance being adjusted, one-half of the weight of the globe would be balanced by the other half; and thus a moderate preponderance of weight being added, or an equivalent amount being subtracted on the one side, would cause a change of axis, in a manner which I have practically illustrated by a simple experiment with an artificial globe so mounted, which I have exhibited to the satisfaction and conviction of many, and shall be happy to show on any future opportunity. It appears to me that the actual geological evidence of climatic change points to this, and to no other manner of axial change. Such a change of axis would also inevitably produce a universal deluge.[3]

Secondly, it may naturally have occurred to the reader that to have proved a meteoric origin for the chalk and flint formation points onward to a yet more extensive inference, which may modify the whole geological theory of the earth's crust. For, since the materials of the chalk and flint formation have come *ab extra*—in agreement with that most ancient doctrine handed down by Leucippus, which is so obviously analogous to the now accepted nebular theory as even to be naturally deducible

[3] See this demonstrated in my work, "Physical Facts and Scriptural Record," and the change illustrated by the established facts of terrestrial magnetism, and by the difference of the inclination of the earth's equator from the inclination of the moon's orbit to the ecliptic.

from it—can that be supposed the only formation which may claim such an origin? The thought is startling, but it may be balanced, on the other hand, by a question based on the alternative theory. For, considering those numerous successive strata and various formations, miles and miles deep in the globe's solid crust all the earth over; and, admitting the deepest stratum containing vegetable remains to have been once the surface of the earth, then whence has the earth acquired those miles in depth of successively superimposed matter? Of the denudation of what conceivable mountains are these strata the detritus, extending as they do in enormous depth over the whole earth? I find the depth of the earth's stratified deposits stated by Dr. (now Sir J. W.) Dawson, after Professor Ramsay, at 72,000 feet, that is $13\frac{7}{11}$ miles; and by another geologist I find the *fossiliferous* strata alone stated to be over six miles in depth. Now Mount Everest, the highest point of the Himalayas, and as yet the highest in the known world, is 29,002 feet high—slightly over five miles. The denudation of occasional mountains of this and various other heights, and of ordinary cliffs of lower elevation, great as it confessedly has been, could not possibly furnish detritus six miles deep, or anything approaching even half that depth, over the wide world. Whence then this enormous and wide-spread deposit superimposed on the lowest level of fossils which indicate the ancient surface? Has not the earth received according to this an accretion of six miles to its radius since then,—twelve miles to its diameter? or say, if you please, it were even half that amount? Is there not something in this to favour the thought of accretion from without? But an increase of radius would cause in

a minute degree a slower rate of rotation; just as a longer pendulum swings more slowly than a shorter. And as an accretion of materials from meteoric sources is still slowly going on, a very minute decrease of the velocity of rotation may be expected to continue. Accordingly it is remarkable that astronomers of late, since Professor Adams's correction, in 1853, of the calculations connected with the secular acceleration of the moon, have come to the conclusion that the earth's rotation has been, and is, getting slower in a very minute degree;[3] which they have been exercising their ingenuity to account for, but which may have in these facts a sufficiently patent explanation. Is not, then, that ancient traditional, perhaps even patriarchal doctrine, which Leucippus had got hold of along with other parts of the philosophy brought by Pythagoras from the East, well worthy to be regarded as the more consonant with reasonable probability and with known facts, though extensively modified by other causes known to be, and to have long been, in operation?

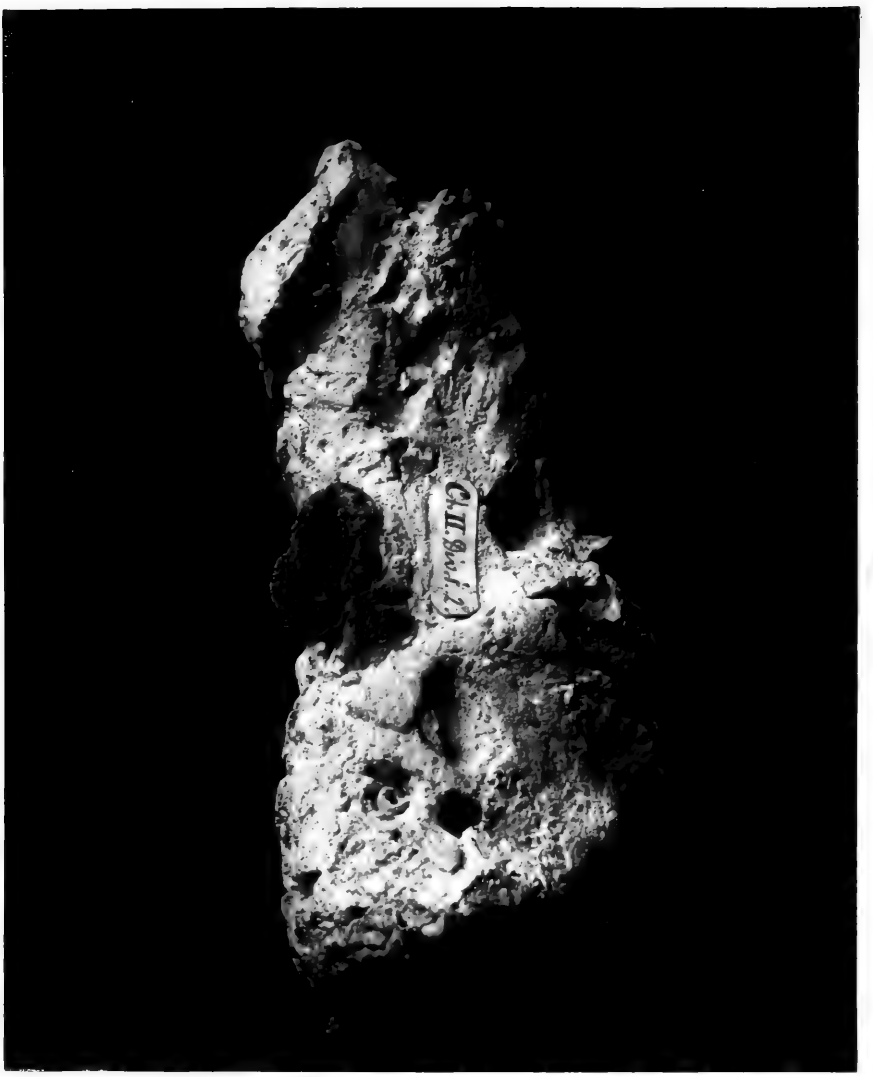
I must be content to leave these questions. It is of more immediate importance to observe that the subject may be shown to have a bearing on the question between the ancient record of the universal deluge, and the alternative modern hypothesis of a deluge of solid ice instead of water, with glacial ages upon ages of ice from three thousand to eight

[3] See, among other authorities, M. C. E. Delaunay, "Sur le Relentissement du Mouvement de Rotation de la Terre." 8vo. Paris, 1866. The subject is popularly referred to by the late E. B. Denison, in his "Astronomy without Mathematics," 3rd Edit., 1867 (Christian Knowledge Society). Mr. Denison states that M. Delaunay's conclusions are accepted even by the late Astronomer-Royal, Sir George B. Airy.

thousand feet deep, covering Europe and North America; and this while the earth, according to Sir William Thomson, was only very slowly cooling down from a state of fiery fusion to its present temperature. I have not exaggerated. These things are according to the now fully accepted theories of the most prominent of the late and present geologists :—ice, from three times to eight times the thickness of the great Antarctic ice-barrier, covering a great part of North America, and the whole of middle and Northern Europe, including Switzerland, the British Isles, and Scandinavia, for hundreds of thousands of years. This is given us as the scientific substitute for the scriptural record of the universal deluge; but the superiority is not manifest to all. It is evident also that the twenty millions, or two hundred and forty millions of years for the cooling down of the earth from fluid incandescence to its present temperature, may now be dispensed with; and there are some other periods, such as those hundreds of thousands, or a million of years, for the freezing of the earth in glacial ages, and thawing again, which may at some early period be similarly found unnecessary. On this subject, to borrow the sentiment of Cuvier, "I am well aware that some naturalists lay prodigious stress on the thousands of years which they can call into action by a dash of their pens," but I myself do not indulge in that facility, nor incline to acquiesce in it.

GILBERT AND RIVINGTON, LIMITED, ST. JOHN'S SQUARE, LONDON.

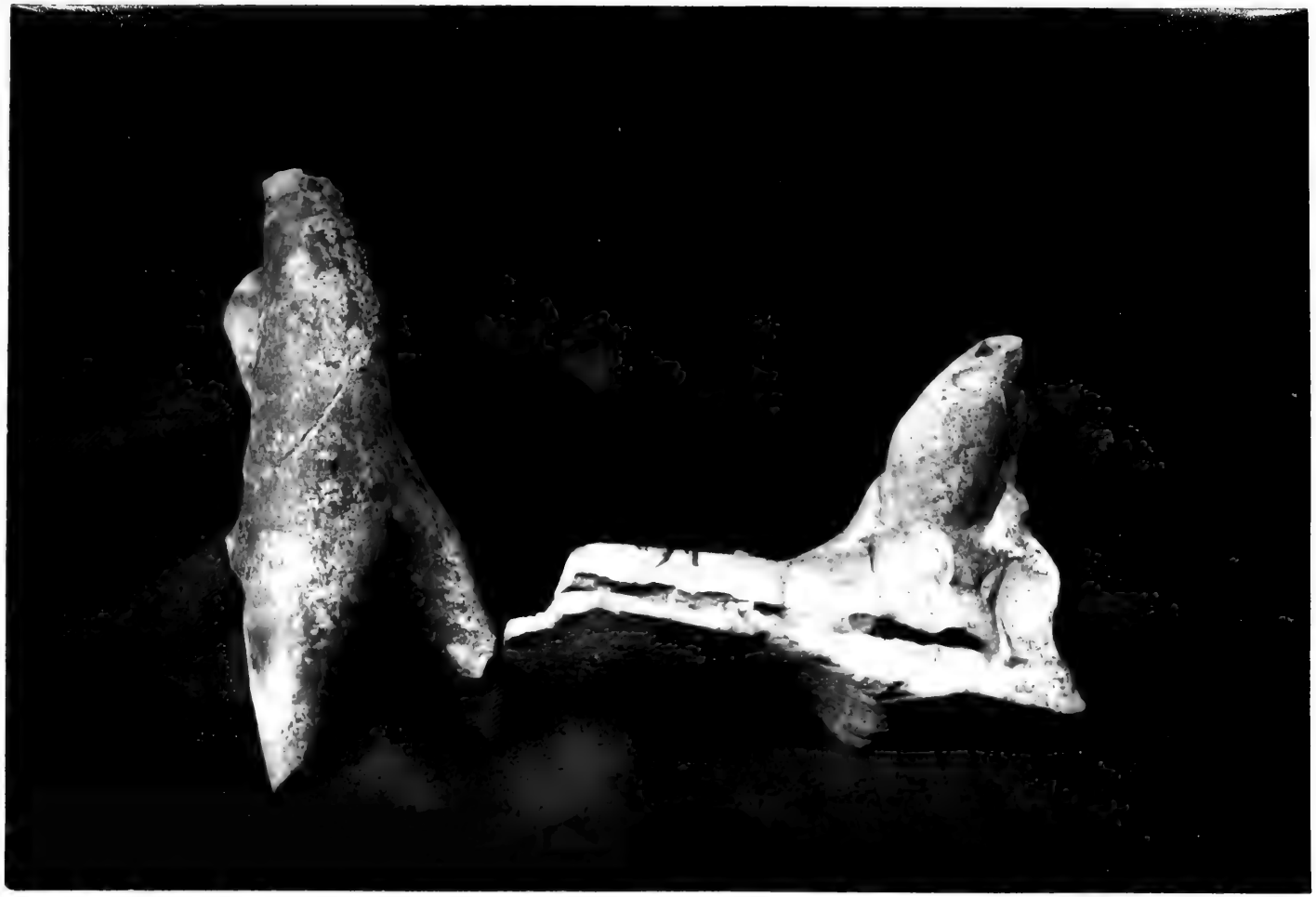
Fragment of decayed Tree Root in flint, shewing part of the rotten interior.



Fragment of Tree Root with Fungus adhering to it, in flint.

Fragment of Tree Root, shewing the decayed interior, and the outer bark partly separated from the inner wood—all in flint.

A Bean Pod, small Bulbous Root, Gourd, and Pear or Fig not fully grown, all in flint.



ARROWY FLINTS.

1.—*Two which have touched and adhered together in their descent.*

2.— *One which has come down upon two tabular layers of flint not yet hardened, pierced through the upper one, dinted out the lower, by the elasticity of which it has been partly forced back, drawing up the edges of the upper one with it.*

14

BY THE SAME AUTHOR.

Demy 8vo, Cloth.

PHYSICAL FACTS AND SCRIPTURAL RECORD; or, Eighteen Propositions for Geologists. Pp. 265. Price 8*s.*

EGYPT'S RECORD OF TIME to the Exodus of Israel, critically investigated; with a Comparative Survey of the Patriarchal History and the Chronology of Scripture; resulting in the Reconciliation of the Septuagint and Hebrew Computations, and Manetho with both. Pp. 570. Price 10*s.* 6*d.*

THE CHAIN OF AGES Traced in its Prominent Links by Holy Scripture, from the creation of Adam to the close of the First Century of the Christian Era. With Notices of Contemporary Gentile Chronology and careful Investigation of the Evidence from the Original Sources. Pp. 714. Price 14*s.*

LONDON:

SAMPSON LOW, MARSTON, SEARLE, AND RIVINGTON,

CROWN BUILDINGS, 188, FLEET STREET.