INCIDENTS

IN THE

BIOGRAPHY OF DUST.

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BIOGRAPHY OF DUST.

BY

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"O light inaccessible, in respect of which my light is utter darkness; so reflect upon my weakness, that all the world may behold thy strength."

—QUARLES.

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PREFACE.

PHILOSOPHERS have said that "there is a reason, a meaning, and an end in nature." We Dusts require more than this—a proof of the reason, a result of the meaning, and a continuance of the end.

Organic structures have their ends, but their constituents return to their respective elements for future use. As long as the sun warms the elements there must be a continuance of the end.

A result of the meaning is found in a constant reciprocity of action. Gases, moistures, dusts grow upwards from the earth, and return to it again. Moisture is drawn up from earth into the atmosphere and falls back again. Dust is taken up into the air and falls again in its atomic, or in a concreted condition. These and other actions perpetually vary the elemental characters. Nature reciprocates by varied fabrics.

The reason for a beginning rests with the Supreme

Creator. His light and heat acting on the elements of this sphere fulfil His intention—"Increase and multiply and replenish the earth." The condition proves the reason.

The manner of this replenishing has been a constant source of discussion with curious men. Nature has one system with varied action; she is bound to that system by never-changing laws. We Dusts claim a share in that system, present and past.

As long as we rightly interpret the laws, in the brief chapters before us, we must place the truth before our readers. If we diverge accidentally from the law, if we overstrain our analogies or deductions, we join the gang who never follow cosmical law. It has been said that one opinion is as good as another; we leave our ideal, when unguided by the infallible laws of nature, to the judgment of those who will take the trouble to think of them.

We treat of cosmical action under one visible law-giver, the sun. His agents are the air, the water, and the dust, individually or as a united trinity. There are no new things in the main points before us; ancient philosophers were on the same tracks, but modern schools have tried to obliterate the spoors; since we began to trace them, modern experiments and discoveries have tended in the same direction.

We endeavour to explain the law, to point out the actions of the agents so familiar to all. The results of these actions are seen and felt daily; similar results happened from the beginning. Visible results vary with change of force and material, but the great laws never change; they are now as they were in their beginnings, and ever will be.

We try to place the beginning and ending of each incident fairly on our pages, but the distances are great, and we cannot arrange the focus for every eye. May we imagine for a moment how they will be seen?

Those students of Cosmos, who have gone so deep into the subject as to know that many fashionable geological structures have no visible or tangible foundations, will look upon our repetitions with some attention. The short-sighted dogmatic sciolists of the present Plutonic school of geology will be ready to explode us.

Those who object to present geological teaching, these are many, will wonder why they did not see the sign-posts now pointed out.

Those who have observed for themselves the actions of the laws on the elements, will recognise in our incidents the results of those laws.

If one or two can see the far-off natural horizons, in which we gaze with never-ending admiration and wonder, we may yet be permitted to see the great vistas of cosmical facts opening out for general view, while young, vigorous, and independent thoughts disclose the beauties and the truths of nature to the satisfied eyes of men in a full biography of dust.

H. P. MALET.

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THE BIOGRAPHY OF DUST.

CHAPTER I.

INTRODUCTORY.

THE earth consists of air, water, and dust.

Air is the envelope of, and pervades the whole earth.

Air is composed chiefly of oxygen, hydrogen, and carbonic-acid gases.

Water occupies a great portion of the surface earth.

Water is composed of oxygen and hydrogen gases.

The dry land of the earth is dust.

Dust is now chiefly composed of everything that grew or lived on earth, mixed with the dust, from which all things were created.

Everything that lived or grew was composed of air, water, and dust.

These three elements therefore compose this earth.

Air and water are active, dust is the passive element.

The earth gains heat from the sun—cold by its absence.

Air and water expand by warmth, and contract by cold.

The sun is therefore the cause of expansion and contraction.

The air and water are warmed on the centre of the earth—the equator.

They are cooled at its extremities—the Poles.

As they contract by the cold, they are supplied by the warm.

As they cool, they return to warmth.

There is therefore a constant circulation.

Circulation of air and water produces force.

Force acts on dusts.

Dust is moved on dry land and in the water.

Water and air occupy the place of the dusts they move.

These movements cause subtractions on the surface and on the water bed.

Both are therefore lowered in places.

The surface of the water is therefore always sinking.

Dust is therefore left dry and high.

Mountains are caused by the sinking of waters.

The sinking of waters is due to the sun.

Mountains are therefore due to the sun.

The sun gives heat.

Heat absorbs moisture from the earth.

Cold condenses moisture in the atmosphere.

This moisture falls upon the earth.

Moisture sinks into, or runs off the earth.

When it runs off, it makes surface rivers.

When it sinks in, it makes subterranean waters.

In all places water is a force.

Subterranean dusts are moved by this force.

Strata are left without support.

Strata, when unsupported, subside by gravitation.

These actions cause landslips, subsidencies, fractures, earthquakes.

The sun is the cause of these phenomena.

There is vegetation on the earth.

Vegetation receives moisture from the dust.

The sunlight attracts this moisture.

This moisture ascends a stem, a blade, a leaf.

Each kind attracts from dust, air, and moisture all that is necessary for its maintenance, its reproduction, and its exhalation.

The sun is the lawgiver to vegetation.

There are animals on the earth.

Animals eat that adapted to their wants, and their reproduction.

Their food is produced by the dust, air, moisture, and the sun.

The sun is the feeder of the animal.

The animal and the vegetable return to dust.

Dusts are deposited with like—like adheres to like.

Nothing is lost of heat or force.

Dusts retain moisture, air, and heat.

There are gaseous and non-gaseous dusts.

There are combustible and incombustible dusts.

Dusts undergo pressure by the law of gravitation.

Pressure condenses dust; dust condenses heat.

Heat acts on the dusts.

Combustible dusts ignite; gases expand.

Condensed sunlight is set free.

Eruptions ensue.

Volcanoes are caused by local action.

The sun is the root of these phenomena.

The root of the sun is the Creator.

The earth is as it is, because the elements have not forsaken " His laws."

CHAPTER II.

INTRODUCTORY.

It has been said that this earth originated in hot vapour thrown off by the sun.

It is said that this hot vapour is still enclosed in the earth.

That the external crust contracts on cooling, and that corrugations and mountains are formed by these actions.

It is said that volcanoes, hot springs, and an increasing heat, with depth, in the earth are sufficient proofs of the internal heat.

No two wells, mines, or excavations, from the same level to the same depth in varied soils, have the same temperature—all have their own pressures and their own causes for their respective heat.

Every hot spring, every volcano, ejects its own causes of heat.

If there are local causes for heat, we may dispense with other causes. There is no law by which hot vapour, as a mass, could have been detached from the sun. There is no proof of an interior fire in the earth, and no occasion for it—all the phenomena, supposed to depend on it, must be dependent on known universal laws.

It has been said by some, and it is believed by others, that this earth has been clothed and peopled by evolution, natural selection, and the survival of the fittest. Where was the beginning? a creation! If one was created, why not all kinds?

If the peopling and the clothing of this earth had been left to the survival of the fittest, to natural selection, or to evolution, they could not have been as they are, because they could not have been under the law. There is no sunlight in the theory—no root, no Creator, no God!

Nature has not forsaken His laws. The earth is therefore as it is. Man is as he is because he has or he has not forgotten his Creator; because he has or has not forsaken His laws.

CHAPTER III.

INTRODUCTORY.

The two preceding chapters are epitomes of those that follow.

The first is a collection of axioms gathered from the general text. The evidence of their truth runs through the whole.

The truth of the whole is proved by the natural sequence of action, and result.

Every action belongs to cosmical mechanism.

These mechanisms have been repeated from the first action of elemental matter to this moment. Cycles, years, seasons, days and nights, ocean currents, the ebb, the flow of tides, storms and calms, are all repetitions of cosmical attention to the law.

We see the effect of the law on the elements of to-day, we trace similar effects all through the deposits of the earth till we get to that period when no organic structures gave their dusts to burial.

In that period we trace the law in its primeval grandeur, in those vast structures below the supposed base of the so-called Silurian system, where siliceous rocks of the old sea-bed supplied the sand-dusts to form the buttresses of the dry land.

All available material was, and is, taken from one place to be deposited in another.

We see the rain fall upon the earth; we see the rivers fill, and subterranean waters rise.

We know that these waters are forces, and that they take the sun-born productions of dry land to the sea.

We know that these productions retain their characters in deposit.

We know that the great currents of air and waters are persistent in their actions; that the water is loaded, season after season, with similar materials; that the warm gaseous and the cold non-gaseous deposits are conveyed constantly to their respective sites; that heating alkaline earths, cold and hot metallic, and mineral matter, are all lodged in their separate deposits.

These mechanical agencies are on so vast a scale, that man has never comprehended them. By tracing each action back to the law, we find proof of the law, of its never-failing action, its for ever changing results.

Under this tracing every formation in this earth becomes a visible and tangible proof of the obedience of the dusts to the agents of the law—evidence of the certainty of the axiom relating to it.

The second chapter shows that, in following back cosmical actions to their causes, we find reason to differ from certain geological schools, as well as from other theoretical teachers.

We cannot discover that their foundations are visible or tangible.

It will be as well to mark the difference between geology and cosmogony; the one is a knowledge of cosmical law, the other a discourse of things in the earth.

The two subjects are very different, but geologists have ventured to mix them. Where their interpretations are unsupported by law, we have endeavoured to point it out.

If our structures can be proved to be without foundation, we shall be curious to see how the elemental actions are interpreted.

Nature is open to all; her ostensible law-giver, her agents, their actions are always before us.

Dusts are for ever under their influence.

We beg of those who have patiently fathomed these introductory chapters, to follow us through a few incidents in the ancient, but still beginning, Biography of Dust.

CHAPTER IV.

SOME INCIDENTS IN THE BIOGRAPHY OF DUST.

"Who hath measured the waters in the hollow of His hand, and meted out the heaven with a span, and comprehended the dust of the earth in a measure."

How few of those who tread on us now imagine that we had a beginning, that there was once a solitary Dust, with no one to think of him, no one for him to think of. Our present condition is so utterly antagonistic to solitude, we are so innumerable, so indestructible, so all-pervading, that individuality seems improbable or even impossible. Our little ancestor is in fact a forgotten atom; we, his children, in our vanity and pride of numbers, have often ignored what he has done for us; in our turn, we are not only despised and detested by all of our thinking relations, but we have been and are maliciously and systematically libelled by those who not only owe their existence to us, but who gain their living by our assistance. It is with a hope of stopping these long-existing scandals that we venture on this Biography. If we are successful we will with pleasure condone with bygones, but at present we only refer to them as far as they are necessary to our tale.

To say that we are an influential family is a mild expression. We occupy every corner of the earth, we are in perpetual circulation, we obey the winds and the waters, we use both for our travelling equipages; we dive to the bottom of the sea, we fly to the utmost limits of the air, and the earth is full of our riches. All the forms that grow, all that live on the surface of the earth, are partly indebted to us for their positions and their conditions; all in the inanimate and animate worlds are constituents of ours, all have borrowed from us on personal bonds, with promise of repayment at uncertain dates. We recognise in their honesty a bright type of our common ancestor, a type that he has handed down to us from the beginning, a type entrusted to him by our Creator, a type that must continue to our end. Under the influence of this mutual confidence, a natural monopoly has sprung up, our business has increased and multiplied, our premises occupy the earth's area, our strongholds are beneath the surface of soil and water, there we keep our accumulated capital, ready for issue on demand. As the treasury of an empire contains types of all its coined issues, so we keep types of those that have issued from us; as coins have changed with emperors, so our issues have changed with epochs. The care and accuracy with which we keep our treasures have very much aided man in preparing his endless index; he can still read coins that were struck 2500 years ago; but time and natural erosion have so obliterated some of ours, that horizons are irregular, and pages have become illegible. As science knows by the metal the era of an illegible coin, so it is now reading some of our nearly obliterated monoliths, with a hope of reading more. The catalogue has grown so long that we cannot stop to examine it critically; we shall use it as we require it, without lingering over the pleasant scenery by the way, as so many have done; but in examining our treasury we shall be guided by one great rule—the dust of yesterday is covered by the dust of to-day; by adhering to the context we hope to trace back the history of our great forefather. As coins circulate under the capricious and artificial laws of commerce, so we circulate under the fluctuating actions of the laws of nature. Every atom that we lend is converted into something else by the borrower; every loan repaid to us comes back in a character different to our issue. Some of our customers are very minute; as small coins circulate through many hands without much consideration, so our small constituents pass through many organisms; in every instance they are altered from what they were. Thus the invisible herb and the largest tree, the microscopical insect and the whale, have their separate and distinct uses for us dusts. We know that creatures and vegetations are innumerable, no two of them are alike in their mechanism, their chemistry, or appearance; types are for ever multiplying; as they do so, we benefit by the increase, and thus, as Professor Tyndall expressed it in his oration to the British Association at Belfast, "varieties are continually produced."

Under this still beginning, never-ending system, such great changes have taken place in the character and appearance of dusts, and our creations, that a growing confusion has crept into those histories or details of our family, which man, from the time of Solomon, has so often presented to his fellow-creatures. Perhaps few of those who have done so have felt their own smallness so acutely as we do; yet we accept the same temptation as they did, and sit down with a hope of correcting some sign-posts, as well as of erecting another, which, with the aid of our delicate clue, may assist some future traveller to the long-sought goal.

We have rested on the highways and byeways, on plains, on valleys, and on mountains—we have drank of the brooks, the rivers, the lakes, and the seas—we have dwelt in the mists, the dews, the rain, the hail, and the snow—we have known the calm, the breeze, the storm, and the hurricane—we have heard the thunder, and embraced the lightning—we have basked in sunshine, and shivered in the frost—we have been changed and broken up under the forces of all. Yet, as Tyndall expresses it, "however small the parts, each carries with it the polarity of the whole." We think that we have a clue to guide our trembling footsteps. We warn those who attempt to take it up, that it is weaker than a rope of sand, that it will not bear the grasp of a drowning swimmer, or sustain a stumbling runner; we ask the patient, in a spirit of affection, to take up the clue, and follow on.

The Bible, on which we love to rest because the chances of disturbance are so often few, tells us that our Creator occupied two days of His time in preparing the elements to make dry land; on His third day the dry land appeared; from that moment there was dust—a glittering finger-post on ocean's vast highway. From the present moment, back to the nursery of legendary lore, man has been puzzling his brains as to what came next. We have a good deal to say about the infancy of our ancestors, but, to enable those who follow the clue to comprehend its meaning, it will be well to clear off a few cosmical mists which the caprice of man, for his varied purposes, has gathered around us. Perhaps there is nothing more wonderful in nature than the reasoning faculty of man. He may not have been created with it: it is even said of him at this present moment that he only varies from cattle by the lack of horns and tail; but he has, said the Lord God, "become as one of us, to know good and evil." If we accept this dogma, we must also accept, "Dust thou art, and unto dust shalt thou return." In allowing that, we admit that the cosmical dust is the casket of our reason, and, as such, that it must be under the control of the Creator. Dust and reason have been united so long and so intimately; the great religious doctrines of the world have been and are so closely connected with us for good and for evil, that we are not prepared to get rid at once of all the gods and demons denounced by Professor Tyndall in the oration referred to, as published in "The Hour" of the 20th of August 1874:—"Science," he said, "demands the radical extirpation of caprice." On this we remark, that common sense demands the extirpation of caprice, when introduced to the world under the wings of science. Tyndall told his audience that the philosophies of Plato and Aristotle were "noised and celebrated in the schools amid the din and pomp of professors." Curiously he treated Darwin in the same way at Belfast, on the same cosmical subject. Ancient philosophers "felt that to construct the universe in idea, it was necessary to have some notion of its constituent parts"—those parts which the wise Lucretius called "the first beginnings." It does not appear that the science of the present has made more progress towards this point than was made by Euripides or Democritus; but it will appear by and by that much progress has lately been made in building imaginary cosmical structures without any notion of first beginnings, literally without foundations. As long as the Professor alludes to such scientific structures, religion and common sense reject him—they do not understand his meaning when he says, "all religious theories, schemes, and systems, which embrace notions of cosmogony, or which otherwise reach into its domain, must, in so far as they do this, submit to the control of science, and relinquish all thought of controlling it." As long as the casket of reason is formed of cosmical dust, so long will cosmical science and true religion be united: at present there may be caprice in both. Professor Tyndall has shown it; he delights to honour Darwin in the national assembly of professors, in his search after "the origin of species." "With profound analytic and synthetic skill he (Darwin) investigates the cell-making instinct of the beehive;" he "associated himself with pigeon-fanciers," and in reply to the question, "Can nature select?" he replied, "Assuredly she can!" The Professor tells his audience, amidst applause, that Mr. Darwin "shirks no difficulty;" but not feeling sure that his own belief was sufficient evidence of Darwin's science, he brought in the late

Professor Agassiz, amidst elegant oratory, as a witness to the point—"I confess that I was not prepared to see this theory received as it has been by the best intellect of the time; his success is greater than I thought possible." Professor Agassiz avoided expressing his own belief. Some years ago we rested pleasantly on Darwin's ideas: we were disappointed in them, as Tyndall seems to have been, for, said he, after gradually diminishing the number of progenitors, Darwin "comes at length to one primordial form." The Professor naturally asks, "How came the form there?" His answer destroys the pedestal he had set up—"The anthropomorphism which it seemed the object of Darwin to set aside is as firmly associated with the creation of a few forms as with the creation of a multitude." "Let us," he continues, "open our doors freely to the conception of creative acts, or, abandoning them, let us radically change our notions of matter." We will await a postulate before changing our notions. But Tyndall uses the word "grotesque" in reference to religion—past, present, and future. We shall see presently that what he calls grotesque was applicable to the condition of the times, while it is easy to reverse the sentence which he has uttered, and say the caprice of theories may be mischievous "if permitted to intrude on the region" of religion. In the midst of philosophic ideas Tyndall involuntarily returns to cosmical nature: "All we see around us, and all we feel within us—the phenomena of physical nature, as well as those of the human mind, have their unsearchable roots in a cosmical life" . . . "inscrutable to the intellect of man." Into this his "science claims an unrestricted right of search." No one hinders him. Virgil, Dante, Milton, flew up to Paradise, and went down to Hell. The world has been instructed by their philosophic poesy, and the deeper science dives into the dust of cosmos, the more instructive, the more religious will it become; the more we search, the more we find; for points, supposed to be concluded, are not even dreamed of in man's philosophy. Has not Professor Tyndall, in his ardour to reach the mountain peak, mistaken forms of religion for the thing itself—that great emotion of the human mind, that sees "a God in clouds, and hears Him in the wind;" and while finding fault with forms for fettering his fancy, he glides down the snowy slope, and does not show how science is affected.* May we express a regret for the omission and commission? We conclude this subject, by quoting from a weekly paper, "Punch," 29th of August 1874—

* We find that Professor Huxley continues in chaos. In a lecture on the genealogy of the horse, he told his audience "that the existing species of horse had arrived at its present form by evolution from lower forms"—but the Professor does not know the *date of horse existence.* —*Hardwicke's Science Gossip,* July 1876.

"But, even as Milton's demons, problem tossed,
When they had set their Maker at defiance,
Still 'found no end, in wandering mazes lost,'
So is it with our modern men of science."

Looking back on parts of the outlines of ancient theologies or mythologies, we cannot help seeing that the systems were fabricated by man, to work on the emotions of his fellow-creatures. Grotesque though these systems may now appear to professors of modern science, we cannot but allow that they were adapted to the times in which they originated, and that they are still useful and suitable to those amongst whom they found a beginning. There was one supreme God, with His numerous avaters; there were demons in plenty for the followers of Brahma; there were perpetual destructions and reconstructions of worlds, good for the good, bad for the bad; there were oceans of sugar-juice, of spirits, of ghee, and of water; and the ambition of all was led up to a glittering circle of pure gold, encircling the earth as a tire encircles a wheel. We worship the gold still, but not the water.

Buddah varied a little in his system: he had three worlds, three heavens, and three hells. The wants of life were satisfied by circles of land, of honey, and of water, while from the midst of these arose his mountain, "40,000 miles in height."—H. Miller. Are there not parallel passages in our own Scriptures?—

"The hill of Sion is a fair place, and the joy of the whole earth." "He hath made the round world so sure, that it cannot be moved." "A land flowing with milk and honey." "The earth is full of Thy riches."

Since these oriental days of good intentions, we have seen a conclave of priests ignoring the Revelations of the Bible, punishing science, and rejecting the geographical wisdom of Columbus. Passing on to Hugh Miller, we find him saying in his "Testimony of the Rocks," that God did not reveal "the great truths, physical in their bearing," but left them to be developed "by the unassisted human faculties." We put down these unassisted among those who still carry the tails and horns, for every one who can think is assisted by his God.

When we come to separate cosmogony from religion, and to look upon it as a mere physical science, we shall see where present geological teachings lead us to, in reference to the point that we desire to elucidate. Mr. Henry Woodward, F.R.S., &c., has put together so many authorities, touching on our birthplace, that we take up his "Geological Magazine" to illustrate our introduction. In No. 114 we find—"Finite as is our individual existence, we are privileged in forming part of a race . . . which . . . has achieved the power to grasp the most hidden secrets of nature; to investigate its laws, to decipher its monuments, and to evolve our planet's history from the chaos of the past." "These grand results have all been accomplished by finite means; each year our knowledge grows broader and higher, like some mighty atoll in the Pacific, not by vast accessions, but by the accumulated labours of individuals."

There are two points in this history connected with us dusts which we must examine, for the purpose of seeing if the secret of our birthplace has been correctly evolved; we must recollect that we claim it on the first dry land. Some of the present highlands of the earth may have been in that condition, and the question of their formation "has of late occupied many of our ablest and most profound physical geologists." It seems to be generally assumed "that all the phenomena of corrugation of the earth's surface . . . are to be regarded as effects of one and the same cause, differing only in magnitude." The cause is in "a fluid interior;" so that "we are justified" in considering this earth "as cooling by radiation." Under this system rocks are supposed to contract, and "thus through the unequal contraction of the earth's crust," "the first preliminary stage necessary for the commencement of mountain formation would be accomplished."

After these minor corrugations were formed, "sedimentary deposits on the largest possible scale, resulting from meteoric action over the newly-made continents, would begin to accumulate." We are not told what these sediments were formed of, but we shall come to meteoric action presently. Professor James Hall is quoted to show that some "mountain chains are composed of enormous masses of sediment . . . even 40,000 feet in thickness." As the contracting cause had lost its power by its corrugating effort, and as only little wrinkles were formed, it was now necessary to show how these vast masses, accumulated as sediments under water, were "elevated." As the weight of these accumulations was also considerable, Mr. Woodward naturally asks, "Why does the yielding to horizontal pressure take place along these lines of deposit in preference to any other?" The answer is so ingenious, so philosophic, that we shall have to repeat it occasionally in our details. It had been shown by several illustrious geologists, that the accumulation of sediment "necessarily produces a rise of the geo-isotherms, and an invasion of the sediments by the interior heat of the earth;" but it will be recollected that just on this spot, this imaginary heat had already done its duty; the place had got cold, the rocks had contracted, they had formed wrinkles; 40,000 feet of sedimentary matter had settled upon them, millions of years must have passed during this process, and then the whole was lifted up by a new accession of heat from an unknown source. If science could apply this system to its boilers, they would steam round the world with one good heating. As soon as that cooled, a little hot water picked up at boiling stations would renew the boiler isotherms, and the service would go on merrily. We reserve serious notice of this theory till we reach our details; at present we can only remark that under the ordinary deposit of matter, there are soft deposits and hard deposits. When, under the current laws of nature, these deposits fall under the denuding forces, the hard deposits remain, while the soft are worn away, so that we cannot accept a birthplace for our forefather on the imaginary corrugations, or on the greater elevation produced by sedimentary deposits, when raised by the patent lift.

As to the profound physical geologists alluded to by Mr. Woodward, we are sorry to find that no two of them agree as to the manner of the formation of our birthplace, or as to the system in use by the forces employed on that formation; in fact, they cannot say where the one cause alluded to by Mr. Woodward is to be found. We shall show in the course of our Biography that this theory has for many years upset and distracted the minds of inquirers as to "the beginnings," and has induced many to raise great fabrics without foundations. At present we close this part of the subject by saying—

> "No constant furnace burns in realms below,
> No molten rocks in constant currents flow;

But we small dusts contain a heating cause,
By sunbeams lent us under Nature's laws."

In raising his atoll Mr. Henry Woodward has alluded to meteoric action. We have said that our duty is to pass through all the creations of this earth; we said that all these creations repaid their debts, and we have just hinted how we dusts repay some of our debts to the sun: but Mr. Woodward introduces us to foreign matter. We must be careful how we meddle with it, how we allow it to mingle with our circulations now, or how far we may be indebted to meteoric action as giving our ancestor his birthplace. "When," says Woodward (*Geological Magazine,* 114, p. 539), "the great continental areas were originally elevated as vast anticlinals above the general ocean," then "sedimentary deposits . . . resulting from meteoric action . . . would accumulate in the great submarine synclinals parallel to the coast." These accumulations would depend on the forces on the spot. At the present moment these slopes parallel to coasts are the arenas where the last process takes place in triturating silicious rocks; they are rolled to and fro, they are battered against one another, the whole of their earthy matter is washed out of them, and carried on in solution, while the refined silicious sand forms the sea bottom of the slope, or is thrown up in glittering atoms on the shore. The earthy solutions are carried on and on, till the waters, finding a resting-place, leave them as sedimentary deposits on the flat, not the sloping, bottoms. The great sedimentary deposits of the ocean do not settle down on the submarine synclinals, any more than the lees settle down on the sides of the wine cask.

Whatever meaning Mr. Woodward may apply to meteoric, no meteoric action could place the sediments where he wishes; but he touches on a subject which is highly interesting to us dusts, as leaving us to speculate on a higher birthplace than we thought of, and very materially increasing our circulation. As no precise meaning is given to it, we associate the word meteoric with—"No class of rocks offers such varied and marvellous attraction for the speculative and theoretical geologist as do those remarkable bodies called meteorites." There are few things, however simple in themselves, that cannot be converted into sensational subjects. We dusts ought to dance with excitement, when we are told that "many of these have come to us as entire asteroids from stellar space, through which, small as they are, they held their independent courses, and only succumbed (as our planet may, in its turn, be obliged some day to do) to the superior attraction of a larger orb than its own. "These meteorites" have been found in nearly every quarter of the earth's surface, "they are known to fall at all times, over land and over sea," so that "their actual number in each year must in reality be very considerable." The chemistry of these meteorites "teaches us that they yield only those elements which we know to exist on earth, and therefore we may justly conclude that the most distant regions in stellar space contain only a repetition, in varying proportions and combinations of the same elementary substances." Mr. Woodward congratulates his audience on the erection of this part of the atoll, and tells them that "this discovery of the continuity of matter throughout the universe may justly be looked upon as among the greatest results of intellectual effort, and one of the grandest generalisations of modern science." All this has been done by finite means; these are some of the secrets of nature, which man thinks he has grasped. The spheres, the worlds in stellar space, cast their fragments away; some of these atoms fall upon the earth; they renew the oriental teachings in an abstract way; worlds are destroyed and reconstructed; they are made simple cosmical phenomena now, while Brahma wisely used them for the religious and moral emotions of his time.

Utterly despised as we dusts are, we content ourselves with saying here that Mr. Woodward has no proof that the meteorites which fall on earth were ever part or portion of a sphere in stellar space; he cannot prove that any "atoms or systems into ruin hurled," ever scattered their fragments into stellar space; the poet may sing, "Now a bubble burst, and now a world," but science, as the filter of caprice, cannot do so. Mr. Woodward cannot prove that any meteorite, which has at any time fallen on this earth was, as a whole or in the shape of atoms, at any time beyond the atmosphere of this earth; so that there is no discovery of continuity of universal matter.*

As far as we are concerned, nothing troubles us more than any alteration of our cosmical duties. Idle though some of us may be, we are all bound to obey the laws. We are composed at present of all that was once beautiful and attractive, ugly and unattractive; we have the poisons of growths, the odours of lives, the sweets, the acids, and the bitters; we contain all the colours of the rainbow; we are tough, tender, hard, brittle, and elastic, adhesive and non-adhesive; every quality found in any one of our types is partly due to us. We are amenable to the forces of air and water; we descend to the bottom of one, and ascend to the top of the other; our relations with these two elements are so admirable, so godlike, that man has not as yet comprehended them. As we mix with the air we give back to it as vapour the loans of the organisms, that returned them for a time to our treasury. In consequence of these repayments the air

* The latest microscopical examinations of meteoric matter mentioned in the Academy, 22d July 1876, prove the presence of earth matter in meteorites.

retains its balance of power. When we have left our gaseous trusts behind us to mix again with the breath of heaven, to enter into more creations, we retire again to the earth; we retain our atomic polarity, as so beautifully illustrated by Professor Tyndall, on the occasion above referred to. Is it strange that, under the influence of this power, we should unite and concrete as our gases leave us, and then, as having done our duty, is it strange that we should return to the earth in showers of light and gladness? Is it wonderful that man's finite powers have not yet evolved this system? He may glean some of its wondrous beauty by a system that he does know of. In descending to the bottom of the water we dusts retain our gases, our minerals, metals, and our sunbeams; as we give them out again, the colours are used in growths and lives, our metals, minerals, and our gases are used for the same creative purposes, while man uses them to renovate feeble creations, and we remain in the waters for the benefit of those that dwell therein. So long as this earth continues poised in air, and surrounded by water, this interchange of duties must take place. There are three incomprehensibles forming a unity, a wondrous world, a godlike Trinity, each dependent on the other, and in their innumerable actions they have not as yet been deciphered by man.

There is one more point connected with this supposed discovery that must not be here passed over.

The chemical materials of meteorites are the same as the materials which are found on earth. As none of these materials which are found here could have existed as they are without earth, water, and air, it would be necessary for any sphere in stellar space, from which these meteorites came, to have the same trinity; but it is commonly asserted that the heavenly orbs have no atmosphere, that they have varied densities, and consequently varied constitutions. We rather think that similarity of systems must be proved before we can claim our origin from stellar space. If this similarity can be proved, there are fixed laws of attraction and gravitation, which, in our humble opinion, would be very antagonistic to any sensational arrivals on this earth from stellar space, and equally so to any departures from us to those regions.

In the course of our Biography we shall have to touch on these points again; we cannot now rest on this mythical atoll as a birthplace for us. We foresee dark whirlwinds, and smothering dust-storms, but we can follow the example of the wandering Bedouin, and while he repeats his prayers to the sand, we can whisper to our relations—

"No chance ejection from another world,
No careless dusts on stellar space unfurled,
No new attraction for a falling star,
No finite thoughts our infinite to mar."

In other words we cannot accept a birthplace for our great ancestor from stellar space, from igneous causes, or from any source independent of man's cosmical Creator. We are bound up in the last, we are the cause of the second, and the first is not proved. Those who try to throw dust in the eyes of others may chance to have it returned; those who build fabrics without foundations may chance to see them fall; and those who trust to finite thoughts can never get beyond them.

The Dust of this earth is not as yet comprehended, its atmosphere is not understood, and its waters are not measured. We go on, trusting to our delicate clue, with a hope of measuring, understanding, and comprehending the birthplace and some of the results of the Birth of Dust. We will endeavour to build on sure foundations, never to be independent of a great "First Cause:" and as long as we are true to that, we cannot be opposed to science in its truth.

CHAPTER V.

THE BIRTH OF DUST.

"He hath founded it upon the seas, and prepared it upon the floods."

"Let the waters under the heaven be gathered into one place, and let the dry land appear, and it was so."

We head this chapter with those words, not only because they belong to the Bible, upon which so many of us Dusts love to rest, but because in the course of a reasonable long life, and a tolerable acquaintance with the works of nature and the books of man, we have never met words which harmonise so well with the actual results of the great cosmical laws, or which convey so clearly to the mind the forces, their actions, and the materials that must have been employed, surely but slowly, preparing for the birth of dust. The long-expected event excited much attention; a great deal depended on it; all the elements were required to attend, all were obedient to the requisition; Old Time, with his virgin scythe, superintended the preparations of the whole.

We have said, and we repeat it, that the dusts have nothing to do with the beginning. Solomon told us it was "unsearchable." Professor Tyndall, the latest authority on the subject, told the British Association at Belfast, that "all we see around us, and all we feel within us, the phenomena of physical nature, as well as those of the human mind, have their unsearchable roots in a cosmical life." We hope to comprehend some of the so-called phenomena of nature; but the root must remain incomprehensible. Look where we will, think how we may, both senses find the horizon utterly undefinable. The deepest science of the present is no nearer the mark than Solomon was.

It is far within the limit of that horizon that we look for the birth of our ancestor. Long previous to this event heaven and earth were created; the waters were divided by the firmament. Light and darkness made the day and night. The second day, that comprehensible measure of incomprehensible time, had passed away; two measures of eternity had run out; all that was done in those measures was done by law. Those laws gave direct proof of supremacy; they were infallible; they have continued from eternity till now. The three elements affected by the laws—earth, air, water—were composed of, and divisible into, many parts; each part, and the whole, were amenable to the laws. The heavens around these elements, with all the hosts of suns, and moons, and stars, all moving, all at vast distances from one another, all occupying infinite space, were and are subservient to these laws; each performs his duty, each fills his cycle, all are under one control, the Creator, our God, the "Great First Cause," so little understood.

As the winds and the waters move now under the influence of cosmical laws, so must they have moved from their beginning; as the earth submits to their forces now, so must it have done from the time they began to move. The earth allows the permeation of air and water, the latter compresses it; and air compresses both in its never-ending embrace of love, of light, and of vitality.

Under the united influence of the three elements, the preparations were progressing beneath the floods; the foundations were at the bottom of the waters. In the third day of God's eternity "the waters under heaven were gathered into one place, and the dry land appeared;" at that moment this great cosmical mother produced little dust.

Looking at ourselves to-day, we know that we come from something; something, therefore, existed before us. What that something was is of no consequence just now; we will claim our heritage presently. We must consider the manner of the birth, the locality does not concern us.

We see that atoms, or molecules, as some delight to call them, settle down in quiet places from a dance in the sunbeam. As long as the air sustains us in motion we dance. When the air is still, we rest according to our varied conditions. At this present moment we see ourselves on the table, the books, and the inkstand; if we were not carefully removed daily, we should soon bury them, as we buried Tyre and Sidon. As the air moves, carries, and disposes of dust, water may do the same; but the atom, or molecule, which is capable of forming dust out of water, has to change its condition before taking its place in our family circle; so that we must look at it first in its damp condition, in combination with the forces to which it is liable.

We presume that the first water rested on earth. When the waters were moved, the bed was eroded; the atoms so eroded were as liable to the forces of the water as dusts were to the forces of the air. They were moved along as drifts; they were carried off in suspension or borne along in solution, they subsided in quiet places, they sunk under the law of gravitation, they stopped for want of force to move them, or some obstacle prevented further progress. We can see similar actions going on in our seas and our atmosphere to-day. As our drifts, our mud, and sandbanks grow now, so they must have grown from the moment that the waters moved away matter from their bed.

Vast regions of the ocean bed are now disclosed to us by the elaborate reports of Captain Nares, of H.M.S. "Challenger." He finds that "the rocky nature of the bottom indicates a considerable movement of the lower stratum of water." In one place "the sounding-rod was filled with decomposed rock," which was evidence of the process of erosion. Red coral was found, at a depth of eighty fathoms, in the Atlantic, with a temperature of 52°, the same as on the coral beds of the Mediterranean. The growths indicate a comparatively quiet sea. Coral mud was found at a depth of 2450 fathoms, telling of erosion and removal. Diatom and globigerina ooze-beds were found at great depths, proving a sinking by gravitation; clay and mud, of varied sorts, at varied depths, proved long-continued trituration of soft materials. Sand, gravel, stones, and rock found at smaller depths, all indicated currents of varied forces, all laden with materials of varied sorts. The dredge showed that occasionally various deposits were going on at the same time, due to change in the force of currents, or to changes in the material liable to the currents. We have thus the most satisfactory confirmation of constant motion in the waters, constant erosion of their bed, and constant removal of matter from one place to another.

We are bound to take another view of these actions for the purpose of discovering, so far as we are able to do so, the nature or condition of the atoms liable to them. There was a time when the movements or the circulations of the water were without control; when there was no dry land to bid the waves "be still," when the currents met with no interruption, except from the inequalities of their own beds, inequalities which they had made. It is of no consequence here whether the circulation was caused by the varied gravity of the waters, by the expansion of the warm, by the contraction of the cold, by the influence of the winds, or by cosmical motion; we know the circulation exists now, and we may safely assume that there were currents that had a free passage from the equator to the poles, and from the poles to the equator.

On what material did these cosmical forces work? Man has divided what he knows of the strata in the earth into systems, groups, and epochs. The last epoch called the azoic, or lifeless, contains the group of gneissic and granitoid schists, under the so-called metamorphic system. These schists are found in stratified condition as water sediments, on the tops of the highest mountains, on the level earth, and at the lowest depths to which man has explored. There is no reason why these schists should not have been deposited at or about the same time; it is of no consequence to our history whether life did or did not exist in that epoch; but the errors of teachers of geology are of some consequence. Mr. Page tells our schools in his Text-book, "We see clearly that a change has taken place in the original sedimentary character of the strata, and that which at first consisted of water-worn *débris*—as silt, clay, and sand—has now been converted into a hard shining and crystalline rock." The conversion is supposed to have been brought about by heat. It did not strike Mr. Page that silt and clay belong to epochs of vegetation and life, so that they need not have been expected in his azoic formations; while azoic times must of necessity have produced hard shining crystalline unfossiliferous rocks, in which the only change that has taken place to our knowledge is the natural change similar to that which takes place in chalk and silicious loam deposits; in which the silex leaves the loam and chalk, forming silicious nodules. In the harder rocks this silicious matter runs into lines, masses, and quartz crystals; no heat is required for these changes, they are inevitable where liquid silex exists. As no human being ever saw these rocks in any other state than they now are, we reject the word metamorphic as fabulous, and go on with our history.

Here and there on the earth's face we find these silicious schists, on our sea and river shores we find sand in all conditions of purity and impurity. In all conditions sands are the remnants of the hard silicious rocks; no other material is so indestructible. It is generally allowed that these schists are "primary" formations; if they are, they formed the old water-bed, and hence the erosions from that bed, when redeposited by water, assume a character very similar to their parents. If our silicious schists are not primary, we may place them in the second place, as triturated remains of the primary silicious water-bed. It is to this water-bed that we look to, as giving up the atoms required to build banks and shallows in those lifeless days; for as these spots are formed now they must have been formed then. Looking at their tolerably pure condition, we see that there was little else to make them of, except that silicious bed from whence fragments must have been broken off. They must have undergone trituration, and rolling up the vast slopes of the uncurbed water's bottom, they must have been worn into the very condition in which we find them—hard grains in a hard shining rock.

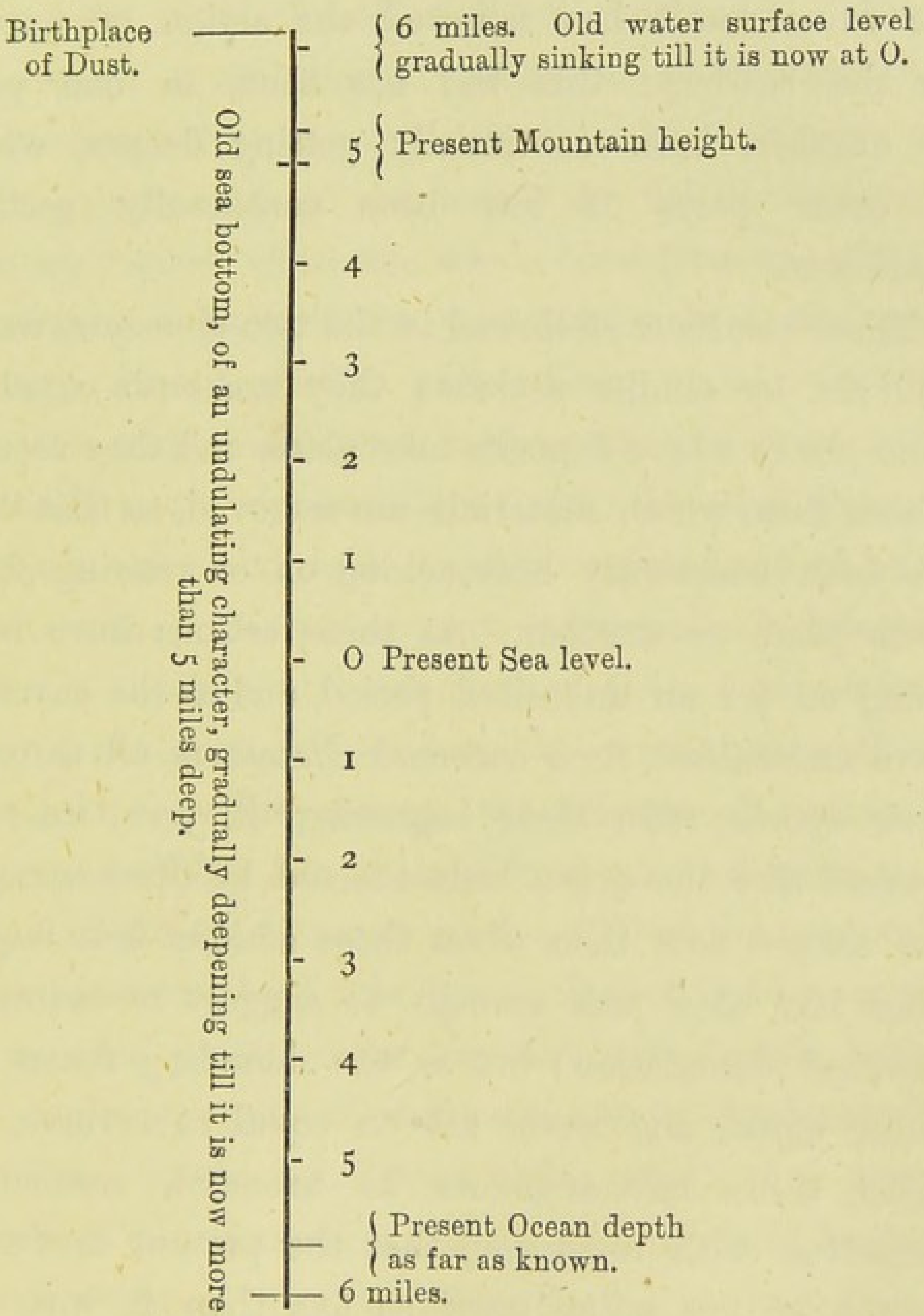
So far, then, we have prepared the foundation for the birthplace; the purest and finest material was sent to the front by the urgent currents and never-resting waves; countless numbers of minute atoms rolled along, every moment becoming more and more finer and finer; while still behind them fresh materials were handed on; the shallow places were getting shallower, the deep places were getting deeper; and we approach a subject of which no reasonable explanation has yet been given.

How were the waters gathered into one place, and why did the dry land appear ?

When we look at and understand the results of natural laws we find them so beautiful, so harmonious, all tending to one end, that as parts and parcels of those results we cannot but glory in the supreme prescience, which created the beginnings of those laws, under which such great events occur. The birth of dust is too momentous an occasion to enter here into arguments with man. We are contemplating this globe as a cosmical mass, composed of three elements, forming a wondrous trinity, uniting in all its parts in obedience to those laws under which each part came into existence, their incomprehensible beginning. To enable us to comprehend the law that we allude to, to watch the obedience of each element, and see the results, we use a simple diagram (see page 41) as a comprehensible measure of actions, going over incomprehensible time, and extending over cosmical space. It shows us the present level of the surface ocean at O—the present depth of the ocean between five and six below, and the present height of the mountains, between five and six miles above the ocean level. These are all the points we refer to at present, but they will be referred to again.

There are two ships engaged at this moment (1873) in examining ocean depths—the "Challenger," from England, and the "Tuscarora," from America. Commander George E. Belknap of the latter reports, under date June 26th, Japan (the "Times," 2d September 1874):—"When about 100 miles east by south from Kiraghassan, or Sendai Bay, on the east coast of Japan, the lead sank to a depth of 3427 fathoms, showing a descent of 1594 in a run of 30 miles." In the next cast, at about 45 miles distant, the sinker ran out "4643 fathoms, without reaching the bottom. . . . On this occasion, when some 500 fathoms of wire had run out, the sinker was suddenly swept under the ship's bottom by the strong under-current." In the Japan stream he found 3493, 3587, 3507 fathoms, and in the next cast the sinker was not detached till it had descended "to the extraordinary depth of 4340 fathoms." In one of the next six casts "4655 fathoms" were found; and, says Commander Belknap, "I have no hesitation in saying that the moment of touching the bottom was as instantly and accurately known at 4655 fathoms, or at a depth of more than 5¼ statute miles, as at 1000 or 100 fathoms." Captain Nares remarks on the section between Bermuda and Sandy Hook:—"The soundings show that there is a remarkable hollow, 3875 fathoms in depth, immediately north of the Virgin Islands." In other places in the Atlantic Ocean he found bottom at 3000, 3025, 3150, 3827, and 2600 fathoms, between the Cape of Good Hope and Melbourne; but the currents were frequent, in one place "the stream rushing past as in a mill-race."

DIAGRAM showing the ABSTRACT POSITIONS of EARTH and WATER in the PAST and PRESENT TIMES, and the POSSIBLE BIRTHPLACE of DUST.



The deep places are called troughs, gullies, and channels, according to their character, and there can be no doubt but that they have been excavated by the constant action of water currents; so that as river streams excavate channels, gullies, and troughs, the same result has followed the action of waters on the sea-bed; this bed has then, in one part or another, been continually getting deeper, while in other parts it has been continually getting shallower.

These results are followed in the two elements, water and air, by similar actions; they are both expelled from places where deposits take place, and they occupy places from which materials are removed, so that they are both constantly encroaching on or retiring from some place or another. As these actions have been going on for an unlimited period, and as the currents have maintained their cosmical characters all through their epochs, from their beginning till now, we may assume that the ocean beds affected by these currents are deeper now than when these actions first began. Man has been rash enough to suggest measures of cosmical denudation; but as the denuding forces are never equal, and never act on equal substances, we reject these measurements as unsound, contenting ourselves with remarking that the present mountain height of five miles must be less than it was. If, then, the height of the mountains has decreased, and the depth of the sea has increased—as the sea level, once covering the whole, has retired from the mountain tops to its present level, a distance of five miles, we have a reciprocity of action between these measurements, which lead us to our conclusion. There is, however, a complicated elemental action that we must notice before we can reach the point we aim at.

The currents of air and water are not continuous; there are regions where the winds blow from one direction during a part of the year, and from a contrary direction during another part. These aerial currents affect the waters, and their surface currents unite with the winds in the duties before them. In some regions the winds are too variable to affect ocean areas of any extent; though the waters may occasionally be heaped upon the shores, or be driven from them, their action is not continuous. These variable currents, as well as the persistent ones, arrange the balance of cosmical power, and though the forms of land may influence the water and the air, we must not forget that the cosmical configuration of land was due to the continuous, or to the variable conditions of air and water. We have then a great variety of surface shape to consider, all depending on the conditions under which they were formed. We have small and large mud and sand banks, we have them of every possible shape; we have long, gradually sloping shallow places and abrupt precipices below water. Those banks that have been washed up in one year may be washed away in another; while the great currents go on for ever in their season routine of duty, and slowly gather together all the materials placed at their disposal. Under the action of the constant and inconstant elements, this surface earth is now what it is. We have said that the locality of the birthplace is of little consequence to us; we claim the first cosmical dry land wherever it was, but there is a locality that offers an example of the vast labours, and the vast accumulation of atoms. This locality may have been that selected. We will dwell upon it for a brief space, perhaps it will bring us pleasantly to our goal. The region we allude to has its centre in the Himalayan mountain range, extending to Samarcand on the north-west, to the equator and Siam on the south-east. The centre of this long irregular barrier rises some 27,000 feet, about five miles above the present ocean level. Far away from the site of these mountains the southern waters now plunge against the shores of Hindustan; far away to the north and east the northern waters wash the shores of Siberia, Kamschatka, and China. The north-east monsoon still reaches Hindustan from these regions, and the south-west monsoon is still felt in the Himalayas. Long before any of these regions were dry land, the currents of winds and water had unbounded sway; they met upon the site of these high lands, and they are the certain result of a comparative quiet locality between these yearly monsoons. If the "Tuscarora" and the "Challenger" had sounded here at the beginning of the third day of creation they would have found shallow places, with the shallowest of all where Ghaur-Shunker, the source of light—now Mount Everest—and Dhawaligheri, or the circle of light, now raise their snowy heads.

All through the two first days of creation the seasons were as regular as they now are; the whole mass of dust beneath us testifies to the fact. The winds blew, and the ocean moved; both of them gathered spoil by the wayside, and both dropped it where it was wanted between the great cosmical currents. During all that immeasurable time, the atoms came rolling into the trysting-place before the cosmical agents; all along the undulating ocean bed they travelled on slowly but surely; smaller and smaller each atom grew, handing over every moment to the water solutions some of their lighter material, and purer and purer grew the myriads of atoms. As they rolled on, they filled the places of those that had gone before, and as the solutions fell in with quiet corners they also subsided in their masses.

In the midst of the great area alluded to there were seasons when the wind ceased to blow, and when the waters were at rest, when light ripples took the place of waves, and light zephyrs took the place of the monsoons. The zephyr and the ripple dallied with the silver sand; their tiny efforts were still exerted in arranging and purifying. Still the glittering atoms rolled up and rolled down again; still the slumbering wavelets kissed each other, and the bright spray flakes sparkled up between them, to whisper to one another of the coming day.

Reader, have you ever stood upon a glistening sand in summer time, when the pellucid sea-wave broke in crystal purity on the gentle slope, washing up the brightest atoms to your feet? have you ever watched those atoms of hard silicious matter settling down, as if weary of their travels? and have you heard the sigh of contentment from the sands, as the hurrying waters retreated from their labours? If you have, you will comprehend the scene which took place in the Himalayan region many millions of years ago, at the commencement of man's third measure of time. There was a cosmical harmony in the scene, as wavelet after wavelet broke over the site, retiring, and still retiring season after season, from the barrier themselves were building. Higher and higher that barrier grew: weaker and weaker grew the water force as it wandered in growing uncertainty up the glittering slope; fewer and fewer flew the spray-flakes; more and more distant broke the surf-wave; deeper and deeper sunk the ocean-bed; quicker and quicker the cosmical waters retired to their channels; till at last, along the line of old contention, the summer of peace came on, the sound of the ripples died away, no more the spray-flakes dashed across the barrier. That barrier had been prepared upon the floods and founded on the seas, the waters were gathered into one place, and the dry land appeared. The summer breeze stooped down to kiss the first-born dust. Its God looked down from heaven, and saw that it was good.

Far be it be from us—Dust—to assert in wilful dogmatism, that this Himalayan site was our ancestors' birthplace: we do not expect any one to say it was not. We record a cosmical fact that took place somewhere, at some time. It was worked out by cosmical laws, which still exist, and still prepare the mud-bank and the sand, and still erode their water beds; but the material washed up is no longer what it once was. Still, in all that the ocean leaves behind it, silicious matter will be found mixed with the refuse of to-day. All that is heaped up now is supplied by the waters: it is not all eroded from their bed, but before growths and lives were created, there was nothing to work up but the triturated fragments of the old sea-bed. In the present, in the past, all that was heaped up was equivalent to what the waters moved, and consequently what the waters heaped up of old was equivalent to that which they borrowed from their bottom, while every atom taken from thence contributed to the cosmical deepening of the sea.

We now return to our diagram. We place the original surface water-level higher than the present mountain-tops, not only because these tops were once under water, but because they were once higher than they now are. As the waters rested on the highest parts of the banks which were formed under their surface, those parts were for the time part of their bed. As this bed has been deepening ever since the waters moved upon it, that bed must have occupied at various times the whole of the space from six miles above to its present depth. As the troughs, gullies, and channels are deeper now than other parts, so from the first there must have been an undulating bottom, deeper in some parts than in others. The diagram explains the abstract condition.

Under this view of the events that took place in man's third finite measure of infinite time, the waters remain now in the same condition as to quantity as they were then: nothing is lost. The firmament still divides the waters above from those below, their mutual connection is still maintained by a continued process of reciprocal exchange. This exchange is cosmical. The waters below supply the atmosphere, the atmosphere supplies the earth, and its surplus bounty carries away to the ocean all of earth that it finds available, the entire process evincing a supreme power of pre-arrangement of laws, of love and harmony, that of themselves are sufficient proof of one first great initiating cause. We have ventured to explain some of the actions depending on this supremacy; man can see them in their working condition. There is no cosmical rest, no cessation of the atmospheric movements; the ocean currents never stop, and earth, our wondrous mother, is always at work.

Little more remains to be said. We contemplate the scene before us; we see the glittering atoms nestling beneath the summer breeze, ready to obey the first commands. Near this brilliant group, Old Time with his venerable figure sits upon the sands, feeling the edge of his polished scythe. The vista is a long one but we, the despised dusts of the present, wish to claim our heritage. That minute atom our forefather has handed down his glittering purity to us; we inherit his indestructibility and his ubiquity. M. Delesse has just shown us, what we knew before, that we are to be found in all present ocean deposits. We see our glitter in the rocks, on our footpaths, in our fields; we see it in the structure of the water growths; it forms the clothing of the grass, and shines on the highest leaf of the tallest forest tree. The microscopical growths of the waters, those fair links between the animal and vegetable worlds, use us for their habitations. We are lustrous on the feathers of the bird, on the scales of the fish, on the hair of the animal, and the animal man converts our silicious materials into crystal palaces and domestic uses, by purifying us from the impurities of the earth. We were, then, in existence before all this was done. We claim our heritage from cosmical creations, the water, the earth, the atmosphere, and from their beginning, the unapproachable, the infallible great first cause. We claim to be still guided in our way by that light; and as we wander with a faltering step into the labyrinths that we ourselves have formed, we try to read each sign-post as we go. Man in his impatience has lost the clue, and has not read those signs; but he has lit up many beacons to guide the present and the future from the rocks and the ship-wrecks of the past. We cannot descend into the *minutiæ* of life and growth; we go on with the great cosmical movements. In doing so we hope to throw a light upon present shade, and to prove the truths of our postulates. The waters gradually retired into their own depths. By this retiring of the waters the dry land appeared. On the appearance of dry land dust was produced; or, in the words of our heading, "Let the waters be gathered into one place, and let the dry land appear, and it was so." If any one can prove it was not so, and can point out another reasonable cause, with cosmical laws for the birth of dust, we will gladly explore the new path. Till this is done, we shall hold by the system we have here sketched, and say, The Birth of Dust is a reality.

CHAPTER VI.

DUST: MULTIPLICATION AND ADDITION.

"Forsake ye not my law."

Education is supposed to qualify for future duties. Some comprehend the value of their qualifications to themselves. Those who are affected by them comprehend their value better.

It was lately said—"It may be regretted that more care is not taken beforehand to ensure that men should be qualified for the work on which they are to enter."

We have before us the new-born dust, about to enter on the rudiments of his education. The atmosphere and the water are with him, ready to assist in his multiplication and addition, when the Supreme Wisdom bids the three "Increase and multiply."

If we look around at the results of this command, as exhibited to us in this earth, and on the face of it, millions of years after his education commenced, we can comprehend some of the qualifications of our ancestor and his successors, and we can understand that the perfection of the present could not have been acquired, unless the elemental trinity—air, water, and dust—had been carefully educated and properly qualified for the vast and responsible duties on which they were to enter. The earth is full of matter connected with the qualifications of dust, and we bring all nature, past and present, as evidence, to prove that in all our long existence we have for ever attended to the good doctrine—"Forsake ye not my law." It is important that we should explain the meaning of this law before following Dust into his first figures. The word is used in the singular, but the doctrine is addressed to three elements, each being divisible and sub-divisible into many parts, every part of each element having its own separate laws in every possible division, while one law embraced the whole in their combination called the Earth.

No member of this trinity could multiply by itself; and it was absolutely necessary that every fraction of each should so harmonise and combine with the fractions of the others as to come under the great law, and make each product perfect in itself.

The mechanisms of these elemental combinations are now called organisms; they are so numerous in the animal and vegetable kingdoms that man has not finished counting them. Every organism, in either kingdom, is a link in the chain of structures which girds this earth. No two links are of the same form, character, or constitution; each is perfect in itself, holding its own position, with conditions, actions, and forces that never change. Each organic structure is composed of us dusts, assisted by air and water: if there is any perfection to be found, we claim some credit to our family for their strict attention to the edict—"Forsake ye not my law." The meaning of the law is evident from its constructions; every vegetable and every animal is perfect in itself; as each organism began, so has it gone on; as each goes on now, so will it go on to its end, because it is under the law. It has been the ambition of man for many years to discover the origin of these organisms. We must examine briefly how far these discoveries have advanced. If we find that no one has reached the beginning, we may assume that this point of the law is still unread, and that the origins of growths and lives are still inscrutable to man.

On the 12th January 1875, Mr. E. Ray Lankester told his audience at the Royal Institution, that nature's great secret was undiscovered; that the doctrine of evolution or the continued progress of nature was fully established by Darwin; that all reproduction is from ovaries; the egg of a sponge is a drop of protoplasm with a hard nucleus. This is the case with all animals and plants. "Thus all organisms reproduce themselves by separating from their bodies germs like this, and no important difference exists between any two organisms in such matters."

On the 6th January 1875, Sir John Lubbock told his audience at the London Institution, that some plants were fertilised by insects, and there was a perpetual change going on. Insects and flowers were constantly tending to adapt themselves to one another, and altering as to structure and geographical limits.

On the 11th January 1875, Professor Armstrong is said to have observed to his audience, that "plants obtained nourishment through the leaves as well as through their roots, and that the seeds of plants consist entirely of the germ in embryo, which was surrounded by a looser kind of material, which served, in the first instance, as the nutriment for the growth of the embryo."

These gentlemen have explained to us varied actions of the law regarding multiplication: they are all useful, but the secret of origin remains concealed.

The Rev. G. Henslow is said to be the author of a prize essay on "The Theory of Evolution of Living Things." He is said to begin in favour of life originating by evolution; while thinking that his facts point strongly to evolution, he shows that where regeneration was wanted evolution failed. He pointed out that "the wisdom of God, as displayed in the works of creation, is synonymous with the will of God; and so man was made by the method of evolution," "to prepare for a higher life hereafter, for evolution means a succession of steps, each in itself imperfect, but each advancing to perfection, which will be the satisfying of the ideal, in opposition to imperfection or inideality." This is a new phase of evolution, but Mr. Henslow still talks of creation, and still finds the beginning inscrutable. We thank him for telling us that the ideal was before evolution.

In replying to certain questions, the well-known practical gardener and botanist, Mr. J. Daniels, says—"The true generic character of plants cannot be changed by cultivation; in some cases they will vary in structure by accident, and may have fewer or more stamens than they ought to have, as laid down in the Linnean system of botany. The only change that can take place will be extra productiveness by superior cultivation; the distinctive character of the plant remains the same. As far as I am aware hybrids do not change from one class to another, but retain the same parts of fructification as the parents. In hybridising it would be useless to attempt to breed between two separate classes of plants. True annuals could never change to perennials."

The practical man sees that plants retain their distinctive characters, and that separate classes cannot mingle. The theoretical churchman, writing in favour of evolution, cannot get on without something to evolve from in an inscrutable creation.

Putting all these quotations together, we allow that some kinds of vegetations and animals may reproduce with one another, either in the ordinary way of the latter, or by the varied ways of the former; we allow that these reproductions may have a resemblance to their ancestors. These productions may be called evolutions. Jacob began the system with Laban's flocks, and the evolutionists of the present day are no nearer than Jacob was to the still inscrutable creation.

We have to remark on another theory on the increase of this earth. Dr. H. C. Bastian has laboured hard to convince his readers that life is due to spontaneous generation. He subjected certain mixtures to a temperature of 212° Fahr., and then found that these mixtures produced life. M. Dallinger and Dr. Drysdale found, however, that similar germs survived a temperature of 300° Fahr., so that the germs of life in Dr. Bastian's mixture may have been there beforehand, and surviving his treatment came into existence on the first opportunity. In addition to this objection, Professor Tyndall found that no life was spontaneously generated in mixtures when deprived of air. We thus come back to what we said above—no member of earth's trinity can multiply by itself. As these are the latest attempts of science to search for a beginning of creation, notified to the public in the "Mail" of 24th January 1876, and other papers about the same time, we may safely conclude that the origins of growths and lives are still inscrutable to man.

The point now reached is that varieties in plants and animals are limited to their kinds: a thistle does not make an oak-tree; a hawk does not make a pigeon; a porcupine does not produce a camel; a gudgeon cannot make a shark—as far as man knows like produces like. These reproductions happen in the ordinary methods of sexual intercouse, by the separation of organisms into parts by cuttings, buddings, and unitings or layers. If these methods of reproducing were contrary to the law, they could not be done; the fact of their being done is proof that they are under the law. All that is under the law can be done by man, and is done by nature—neither nature nor man can perpetuate that which is contrary to law. Thus each kind of vegetation, and each kind of animal, in continuing their own kinds naturally, or artificially, with all their possible varieties, by all their possible methods, are attending to the doctrine, "Forsake ye not my law." We were told by Richard Owen in 1852: "Nothing seems easier than to distinguish a plant from an animal; in common practice, as regards the more obvious members of both kingdoms, nothing is easier, yet as the knowledge of their nature has advanced the difficulty of defining them has increased, and seems now to be insuperable." Nothing, however, which exists in either kingdom, and that has the capability of reproducing, is beyond the law. In all the counted and uncounted combinations of air, water, and of dust, each of them, individually and collectively, in all their multiplications and additions, aids in forming the harmonious whole that fills the bosom of the waters, and occupies the surface of the earth.

Every organism is a combination of elemental matter, and is, therefore, a part of creation. We cannot see that any other word is necessary to make the subject comprehensible. We may say that water is evolved from air, that dust is evolved from air and water, and that air was evolved from the will of the Creator. We are compelled to trace beginnings to that Supreme Lawgiver who created the sun as His agent for this sphere. If creation did not issue from that Supreme will, if that will had not ordained our laws, if the order to "increase and multiply" was to be carried out by accidental "*natural selection*," or by a chance "*survival of the fittest*," then there was no occasion for dust to go through the education which it has gone through, to enable it to aid in the formation of organisms, and to continue to all these structures the faculty of reproducing their like again.

We understand now that the law gives a similar lineal descent; that as it was in the beginning of creation so must it remain as long as these creations exist. Do we understand Mr. Douglas Spalding, when he tells us that the "bodies of men and all animals are conscious machines, whose movements never escape by a hair's-breadth from the inexorable rule of physical law?" We read the same in Daniel—"Neither have we obeyed the voice of the Lord our God, to walk in His laws, which He has set before us." Man sees the results of his disobedience, and the certainty of the law, in his own weakness and in his hereditary imperfections. Nature, in her integrity, has no imperfections, no weakness, because nature did not forsake the law. Nature is the automaton, man is not, for he has a fallible will of his own, which guides his actions and affects his body. Natural results prove the reality of the law.

We may now say that there are laws, by which all things on this earth are ruled. The visible agent for these laws is the sun; nothing can grow or live without warmth and light. In their individual and collective attention to these laws the air, water, and dust have, by the multiplications and additions, brought this earth to its present condition. The ocean rests on a bed of silicious rock, now covered in most parts with sedimentary dusts that belonged once to organic structures. The dry land has a similar foundation to the ocean bed, covered generally with dusts in varied conditions, nearly all of which are sedimentary, and were once parts of organic structures.

The highest points of dry land are about five miles above the sea level; the sea is about the same depth. Man has delved nearly a mile below the surface of dry land; he has found dusts of present, recent, and past organisms, decreasing in their legible condition, till no organic dust is found in the old silicious rocks.

A conclusion has been drawn from this fact, that there was a time when no organisms existed. We have shown the birth of our lifeless ancestor. We have now to exhibit the reason of that birth, and the meaning of the first dry land.

We may now hear the first command given to this earth—"Increase and multiply!" We may see the vapoury light, and feel the first warmth; we may see the gentle firmament kissing the glistening cheeks of dust, as germs of the future were deposited on its bosom; we may understand that the secret of the infinite was entrusted to His Trinity; and we may comprehend that dust, water, and air at once obeyed the new command.

We may anxiously watch the little roots that sucked the scanty nourishment from the silicious dust; we may feel the gentle warmth that drew the moisture to the early light; we may know that the vapour of the air and the moisture of the dust formed those "looser kinds of material" that surrounded the germ and nourished its growth. We may observe the care lavished, from that time to this, on the preservation of the germ and the embryo; and we may allow a time for both to indicate the reason and the meaning of the first dry land, of the cosmical trinity, and the object of the law. The scene was changing over the surface of the sea-deserted area; its once barren dusts were covered with little spikelets, stretching up their new sprung heads on the morning of their existence; on each green blade a drop of crystal dew was hanging; as the breath of daylight passed along, each diamond tiara dropped upon the dust, each spikelet rose relieved of its burden; the springing of the blade, the fall of the dew-drop caused the first gentle murmur of praise from the new creation; from that time to this nature has sung her morning hymn.

Time watched the growth, the maturity, the decay; he swept away the tissues and the fibres; they were gathered by the breeze, or they were taken; to the waters, all to be mixed, re-assorted, and arranged in the treasury of dust; they were all repayments and all additions to his riches.

Dusts of vegetation, dusts of water-growths enriched the cold silicious atoms, each mechanical arrangement caused new chemical action. Dusts became varied in quality as they increased in quantity; varied dusts received the varied germs from the ever lavish firmament; varied kinds of looser material protected and nourished the new germs. Waving algæ flourished in the shallow waters; glumes, panicles, awns, and florets spread continually on land, covering its surface and paying their interest as they grew. Each showed the reason of its creation; each increased and multiplied; each grew on under the warmth in the air with the moisture from the dust; each collecting under the attraction of light and heat the varied nutriments necessary for its distinct organic structure, for its reproductive powers, and for its own existence during its allotted time. Then the autumn and the winter scythe came round again, each had done its duty, and each repaid its capital to dust, to air, and to water. The organic structure returned to its elements, each contributing its share to vary, to enrich those elements, to make them capable of greater works.

Dust was busy now with his additions, every organism that had been, added its mite to the area of dry land; as the waves threw up their primeval dusts from the lowest depths, those depths grew deeper and deeper; into those depths the waters continually retired, till by this retiring of the waters, and by the additions to the dust, the dry land was slowly, but surely, spreading out its shores.

Softly and silently the firmament spread its curtain of darkness over the coming scene, as it passed along in all the warmth of heavenly love, to entrust fresh germs to the new-made beds. Dusts from the waters, dusts from the earth, and dusts primeval, were all mixed together in apparent confusion, in certain design, in increasing richness, in growing variety; here water in excess, here gases abounding, here dusts in varied combinations; in no two places were the chemical mixtures the same; on these varied beds the varied germs were deposited for the coming events. Another spring-time tripped along, nature's curtain arose; varied terms of germination, varied kinds of growth, in appearance and in structure, gradually expanded on the surface of earth and in the waters; all the first growths were there increased in quantity, unchanged in quality; amidst the ferns, the lichens, and the grasses, up sprung the herb, the fruit, and the forest trees.

Dust was getting busy; his studies were increasing in complexity. New roots and old roots sucked the moisture from his bosom; new leaves and old leaves conducted that moisture to the light of heaven. Varied leaf and varied root supplied varied matter for the varied structures, and every growing vegetation, as it passed on to perfection, filled up its varied growth with varied qualities and varied quantities of dust, of water, and of air. So refined were these varieties, that while the natural distinction between kinds was carefully preserved, lines of demarcation were drawn between vegetations of the same kind, introducing leaf, stem, flower, and fruit, all retaining their true generic characters, with no two similar in general appearance. The dusts claim to have initiated these varieties, in consequence of the variations imposed upon ourselves; by us conveyed to the embryo; by us nourished from creation to maturity; and by these duties giving to each organism the faculty ordained by nature of reproducing the like again.

Spring after spring fresh organisms joined in the fast-extending morning hymn. Nothing was created without a reason and a meaning; that which was useful for one thing found its application; creation multiplied with its own additions, growths and lives sprung up dependent on one another, and Time came round to gather his harvests with a careful hand, nothing was lost, the organisms returned their gases, their liquids, and their dusts, all to be garnered in their respective treasuries, all to increase the complexities of dust—all to increase the area of dry land.

Man has not analysed the epoch occupied by these first labours of dust; he does not even know the site of the first dry land, or the burial-places of the early organisms: he is now discovering remains of organic dusts in rocks, which may be millions of years younger than the rocks formed by the first additions of organic matter; he delves for old dusts thousands of miles away from our early burial-grounds, and flatters himself that he is discovering the secrets of nature in comparatively recent dusts. Our history requires no recognition of individuals; our cosmical rule is our only clue. The dust of yesterday is buried by the dust of to-day. This dust may be of the moment, or it may be of millions of years. Of whatever age it may be, or from whatever place it came, is of little consequence; it aids in the cosmical formations beneath our feet; a regular, or irregular succession of stratified matter, with organic types so legible, that they give names, epochs, and classifications to strata, till those rocks are reached, which betray no organic types, and are consequently called azoic or lifeless. There are so many cosmical causes by which delicate organisms can be obliterated, that there is a difficulty in accepting the idea of a secondary azoic rock; but, contemporary with these rocks, we may class the strata formed by the multiplication and addition of man's finite measure of time, the third day. During that uncounted period dust had never rested from his labour, but as the time passed on, a clearer atmosphere, a warmer sun, a brighter light, a more genial water, was gathering around his rich and varied combinations. A new epoch was at hand, new studies were to be entered into, with new chemical, and improving mechanical arrangements.

The light was divided from the darkness, seasons became more defined; and man has assigned to this long but uncreated era his finite measure, the fourth day.

In all that period dust was never idle. Organic forms of varied kind, varied uses, sizes, and characters, were produced to fulfil their duties, to increase and multiply on earth. Slowly that earth increased its dry land, by the two great causes working on it, one the perpetual addition of dust to its surface, the other the perpetual retiring of the ocean from its shores.

New dry lands, new temperatures, sunlit days, moonlit nights, wooed the ready firmament for germs to love. New duties arose from new conditions. Dust had to use his tissues, fibres, and cements; there were dangerous forces upon earth, and in the water, dangerous forces in the atmosphere. The new germs required protection, it was provided by the ready hand of the cosmical trinity. Man has never even conceived the delicacy of the manipulations then in progress, new germs had to be nourished by the "soft material;" this material was derived from air, water, and dust; the trinity supplied it in tissue sacks, fibre envelopes, and calcareous shells; no three alike; and if there was a similitude between two, it was that which has ever since existed between the males and females of each kind, alike in nature, varied in appearance, and condition. There were no other materials upon earth from which these preparations could be made, than those which formed our cosmical trinity; there were no other means for their preparation than the natural forces working under natural laws. We see the results in the lineal descent of shell, envelope, and sack, all containing the "soft material," and all nourishing the seed, or the germ deposited by the parent animal or vegetable. Man cannot imitate these wondrous mechanical and chemical systems.

The new epoch was moving on, but so associated with the past, that it is not yet known when the animal world began. Looking at the beautiful reciprocity of nature at the present moment, and acknowledging the necessity of a balance of power between the two kingdoms, we have no hesitation in saying that the animal began as soon as the vegetable supplied its food; the law requires these mutual actions. The vegetation takes in the carbonic acid and gives out oxygen gas; the animal, reversing this system, takes in the oxygen and rejects the carbonic acid gas. Nature then requires an equal supply and demand to balance her system, while organic structures are in the same predicament. If there is nothing to consume vegetation, it becomes overgrown and dies; if there is nothing for the animal to feed on it starves to death. It is not necessary to our history to define life in its beginning or in its priority, we know that life is and that it was. We know that it is now linked to the vegetation, we may be sure that it always was so. We may be sure that a systematic beautiful past has grown on, by the multiplication and addition of dust, into the perfection of the present, not by the labour of dust alone, but by the harmonious working of the cosmical trinity, under the doctrine—"Forsake ye not my law."

Miniatures of this earth's spherical shape were in the waters and on dry land. Some soft, some elastic, some hard, some single, some linked together, some covered with gelatinous matter. Each, formed from and by our trinity, held within it a varied combination of air, water, and dust, forming the necessary nourishment for the germ within. Each sphere, egg, cell, or cist held an embryo life, that would be not only competent to fulfil its duties in the cosmical circle, but was intended to hand on to the future all the varied qualities inherited from dust.

Each sphere, in its own allotted time, gave up its hidden life. Coloured fish escaped from them to swim in the waters; varied reptiles crawled upon the land; and many a coloured plumage fluttered in the air. Coloured flowers opened to the sunshine, and gaudy insects delighted in their sweets. Morning after morning fresh growths and fresh lives joined in the ever-increasing murmur of creation, and the finite measure (the fifth day) of an infinite time had passed away. Wisdom smiled at the assiduity of dust, at the increasing complexity of its figures. The film of the moss, the fibre of the grass, of the fern, the reed, the bush, the tree, the soft fruit, the hard pod, the elastic husk; all vegetation, immovable, varied in kind, varied in their kinds, all links to each other, all existing by nourishment from the same source; no two on the same quantity or quality of air, of water, or of dust. All vegetation growing on the surface of dry land, or on the water bed, giving shelter and food to the movable animal, minute links to the larger animal world; links that are not yet defined, lingering on the margin of the immovable, with a timid approach to the movable, with the strange reciprocity of eating one another, but all doing their duty in their own cosmical circles, all paying interest to the cosmical trinity during their existence, and giving up their capital when time came round to gather it; capital and interest tending to increase the riches and complexities of dust—all adding to the ever-growing area of dry land.

As the law of nature began, so it went on; each organism changed the character of the elements which sustained it, each gave back to nature an altered dust; upon these altered dusts the mysterious firmament left its new-formed germs, again it pressed with warmth and moisture on the earth, again the earth prepared fitting receptacles for the germs of love. All that had been there before increased and multiplied; organic nature spread over the now wide and extending surface of dry land. Amidst the warm luxuriance new cists and new wombs held within them all the varied elemental matter, required to nourish and bring to birth their growing embryos: embryo and its nourishment all of our united trinity.

Dust was full of expectation and of hope; new secrets were entrusted to his care; new figures were placed before him for multiplication; he was experiencing a deeper and a warmer love; unknown fibres drained the moisture from his heart, nourishment was absorbed from his inmost frame; year after year, epoch after epoch, living creatures were brought forth, new creations murmured out their morning hymn, "there was neither speech nor language, but voices were heard amongst them;" quadruped and creeping thing and man had issued from the tissue wombs of dust. The finite measure (the sixth day) had ended.

Dust looked back upon his figures joyously, he had lent mineral and metal; water had provided moisture; air had lent her gases. In various combinations these elemental materials accepted germs from heaven, and under the influence of the warming sun, those germs had been brought to birth. The contracting sea, the spreading dry land, were supplied with organic structures of vegetation and of animal in still uncounted numbers; no two alike in appearance or in constitution; each kind with a varied condition, a varied manner of reproduction, and a varied period of existence. The inanimate and immovable had progressed to the movable and the animate, the unfeeling to the feeling, the insensible to instinct, instinct had advanced to reason.

Dust had not required Anaxagoras, Berzelius, or Thomson to tell him how to divide elemental matter. Without the assistance of Herbert Spencer, he had discovered that, "before there can arrive all those involved relations displayed in the movements of a living creature, there must exist those chemical relations amongst elements, and those structural relations among its organs, by which those involved relations are made possible." In those long-forgotten times dust had done that which Plato expressed—"In proportion as instinct is developed, some kind of conscience becomes nascent"—or, as echoed by Herbert Spencer, "We see by a progression thus wrought out, instinct must in the end *insensibly* pass into a higher order of psychical action."

Disclaiming any share in creating the conscience, we have before us an organic cosmical chain complete and perfect in all its links; every link after its kind, each forged by a prescient wisdom from cosmical elemental matter, each existing link is visible to those who take the trouble to look for themselves; we cannot trust those who argue back to a foregone conclusion, fitting their arguments to their own ideal without any reference to the law. We dusts accept man as the last complete link in our cosmical creation, not an insensible, but a visible, tangible passage from that instinct, which only took care of itself, to a creature conscious of other existence, with a reasoning capacity, a power of consideration, a faculty of judgment, a sense of discretion, and, as he believes, an infinite soul hidden in a casket of dust—the last figure in our multiplication tables, endued with an intellectual force, capable of guiding his physical force into the governance of all created things. It was a great link, a visible distinction in the mechanical formation as well as in the chemical condition.

So vast has this last link of creation become that we dusts sink down before it. A figure formed from our own trinity, an organic mass of dust, has dominion over our abstract atoms, and over all that ever sprung from us. Man, nourished by us in the embryo, born from our womb, fed on our food, with a life and conscience given by our Creator, possessing a limited power over each element of our cosmical trinity, is able to control and handle our life, our electricity, and to distinguish between good and evil. One thing only is withheld from him—the origin of organic existence. Late doctrines show how sacred this secret is still retained. It was entrusted to us dusts many millions of years ago, when "Wisdom was with us, as one brought up with us, our delight;" when she gave us that good doctrine—"Forsake ye not my law." We have kept the secret; the wise man knew that we had done so, and that the secret was inviolable, when he wrote the figurative words, "He placed at the east of the garden of Eden Cherubims, and a flaming sword which turned every way, to keep the way of the tree of life." It is a secret still. We, the elemental trinity, still continue to multiply, and every organism, created through us, retains the faculty of reproduction in lineal descent, with a similar mechanism, a similar chemical condition, and similar instincts.

If we have succeeded in making the law, its agents, and their actions intelligible; if it is understood that there was nothing for the law to act on in the beginning but dust, that dust was consequently the ostensible producer of the first growth, it becomes a natural deduction and a certain sequence that dust was the ostensible producer of the first life. If dust was capable of producing the first in each kingdom, it is fair to infer that, in the absence of other producing causes, and from the fact that every production contained dust in its system, that dust must have aided in the creation of all. If mankind is so begrimed with the word evolution, he may apply it without folly to the gradual evolution of organic structures from the gradual but certain alterations in dusts. It will, however, be as well to know what is meant by the word evolution.

"Chambers's Encyclopædia" couples evolution and involution together. "Involution is the performance of any number of successive multiplications by the same multiplier. . . . Evolution is any method of finding out, from the results of an involution, what multiplier was employed."

We have in our notes a quotation from Herbert Spencer (work not noted)—"Evolution is an integration of matter, and concomitant dissipation of motion, during which the matter passes from an indefinite incoherent homogeneity to a definite coherent heterogeneity, and during which the retained motion undergoes a parallel transformation." The author of this definition required a few hundred pages for its explanation, but a few words will show how far we may trust to its oracular wording.

If we consider a good hen's egg under this definition, there is an integration of matter, but no *dissipation* of motion. When the germ is vivified by warmth, the whole contents of the egg are in motion, passing from two well-defined segregations of coherent matters into the higher defined homogeneity of a chicken, by parallel motion, and transformation of defined materials.

An addled egg, on the contrary, presents an undefined incoherent heterogeneous matter, with a dissipation of motion, by which the matter passes away by absorption into its respective elements, leaving eventually a dry bit of incongruous dust in the shell. As this explanation will hold good through all the *soft materials* which surround and nourish germs in the whole vegetable and animal kingdoms, we may pass over this definition as imperfect and untrustworthy.

Reverting to the first definition, we go back to the idea of evolution given by the Rev. G. Henslow, and find that organic structures must be evolutions from dust, air, and water, with a life evolution from the will of God. Thus the multiplier is the cosmical trinity, as proved by the results of successive involutions in the uncounted evolutions in the waters and on the earth; every one of them formed of figures used by the multiplier.

As far as we dusts are concerned, we cannot object to the word evolution under this definition, but the Rev. G. Henslow used the word creation. It seems to us more applicable to the position, and as one definition only can be applied to it, and as there can be no object in having two words for such an important event, we are glad to accept the intelligible one, not only as less calculated to mislead our relations, but as associating our caskets of dust more intimately with our Creator.

Under the guidance of that Supreme Power, with His ostensible agent for ever shining on us in heavenly warmth and love, we dusts have, from our beginning, increased and multiplied. We have filled our place in the cosmical trinity; all created organisms own their physical condition to that trinity. We may judge of the past by the perfection of the present. If the organisms of to-day are harmonious, if they fill their places in the great cycle of creation individually and collectively, then we dusts claim for our forefathers the credit of a strict attention to their early education. We feel that all around us are affected by those early qualifications, and while looking at present results, we cannot but admire the steadiness, the constancy, and the accuracy with which the elemental trinity attended to the doctrine—"Forsake ye not my law."

All the multiplication, all the addition to and on this earth, is due to that obedience; an obedience, and a resignation sometimes displayed by man; shown to us by Cyrus when he said to his sons, "You will as speedily as possible give back my body to the dust; for what can be more desirable than to mingle with that which produces, and fosters all that is beautiful, and all that is good. It will, methinks, give me pleasure to become identfied with that, which is the great benefactor of mankind."

It is a pleasure to us dusts to meet with such acknowledgments and reciprocities; they give us encouragement to go on with our additions, to lend our nutriments again, again to multiply, again to place fresh dusts within our treasury. To contemplate, in an unmeasured future, our Creator looking down upon His trinity, and upon all things created through it by Him, to find that His doctrine has been still attended to, that His laws have never been forsaken, and to hear Him say, in the continuance of his sunshine, " Behold it is very good."

CHAPTER VII.

DUST: SUBTRACTION AND DIVISION.

"Forsake ye not my law."

If antiquity of custom gives any sanctity to its observance, no custom is more sacred than the destruction of obsolete theories, and the formation of new ones.

Dust was the first to give the example; all that he has done has been done by using the fairest and the plainest products of his multiplication, and addition for his subtraction and division.

As soon as his first products became old, Time became urgent, the law had to be obeyed, the agents, air and water, were obedient, the three elements set to work as an united trinity under the good old doctrine —"Forsake ye not my law."

The results of these cosmical labours are shown in the earth as a whole; it is very beautiful, very harmonious, and full of riches. The details of labour in the subtraction and division, erroneously called denudation, are, at first sight, very intricate and chaotic to casual observers; but our ancestors began at the beginning, they have continued their unbroken regularity till now, and they must continue to perform the same duty, as long as the sun is their lawgiver, with air and water as his agents.

The agents of the law are before us; we see them doing their duty; all the dusts on or in the earth are liable to their actions. These actions vary in places and at times, while the dusts vary in character and condition. Dusts are wet and dry; the latter occupy a surface area of about 53,000,000, the former give a bed to the waters of about 144,000,000 square miles. Subtraction and division are going on over the whole of this space, not only on its surface, but in its interior. We see the figures moving before us in the air, the water, and on the land. The deep-sea soundings of the "Challenger" tell us that the same work is going on at the bottom of the ocean. The springs and the wells are all proofs of subterranean labour.

With certain evidence of action, we have first to look at the material acted on, then the agents. The dry land of this earth is entirely composed of primeval and organic dusts; it is divided by man into one torrid, two temperate, and two frigid zones. The surface is undulating, rising at some points to five miles above the sea-level. Every atom of organic dust in this mass has undergone the action of subtraction or of division, and every atom of primeval dust, that is not contained in the foundations, has undergone the same actions. The waters encompass the dry land. Water falls on its surface, runs in open channels over it, percolates to its interior, issues as surface springs, is found in wells, mines, and excavations, and breaks out of the wet dusts in the sea-bed. Waters are divided into oceans, seas, lakes, rivers, and subterranean. The ocean-beds are undulating, and reach a depth of about five miles below the level. Every drop of water individually, and every body of water, may act as an independent force, and it may act as a force dependent on the action of the air. The water is formed from two aerial gases, hydrogen and oxygen, and is said to contain minerals and metals in solution.

Air, composed chiefly of three gases, is the envelope of the waters and the dry land. Air pervades every drop of water, every atom of dust; it is in every organic structure, it is said to hold minerals and metals in suspension as vapour, and to extend about fifty miles in diameter round the earth's surface, as the sustaining or supporting atmosphere of the earth.

Taking a general view of agents and material, we find them so constantly associated that, as one cosmical trinity, they form this earth with all that is on it or in it; all of this, the dusts, the air, the water, in their united, as well as in their individual actions, owe these actions to the cosmical lawgiver, the sun. As air and water expand by heat and contract by cold, it follows that, as they become expanded by the heat of the torrid zone, both have to fill the vacuum caused by the cold of the frigid zones; as the pressure, caused by expansion, acts perpetually on the perpetual retiring, caused by contraction, a perpetual circulation of the elements is maintained. The warm water runs towards the frigid zones as surface currents, when it gets cold it sinks, and returns to the torrid zone as a bottom current.

A few examples from the deep-sea soundings of the "Challenger," will be sufficient evidence of these actions. On 30th August 1873, in 0° 0′ 9″ N., 30° 18′ W., a depth of 2275 fathoms gave 33·6° Fahr., with a surface temperament of 75°. On the 22d February 1875, in 0° 39′ N., 138° 55′ E., a depth of 2600 fathoms gave 34·4°, with a surface of 75°: all the soundings in the torrid zone give similar results. By the report from Captain Nares, dated 30th July 1874, we find, "On the 19th February, in lat. 64° 37′ S., the temperature of the surface water was 22°, that of the air 30°. . . . The bottom temperature at 1800 fathoms, as registered by two thermometers, was between 32° and 28°." By this report we learn, "In higher southern latitudes, I feel certain that below 100 fathoms there was a warmer stratum of water, extending probably to a considerable depth." This may be analogous to the increase of the temperature sometimes experienced in ascending mountains in the winter. The highest recorded surface temperature was in the Celebes Sea 85°, with 38·5° at 2150 fathoms. We may then accept it as a rule that although surface water temperatures may be affected by the atmosphere, yet as a rule the bottom waters are colder than those of the surface.

The action of the atmosphere is very similar: it is heated and expanded in the torrid zone, creating a perpetual circulation from thence through the temperate zones up to the frigid and back again. At 14,000 20,000 feet of elevation we reach freezing points.

We may safely infer from these actions that the sea level is the line of greatest warmth on earth, that air and water are in constant motion above and below that level, that cold currents of water run below the ocean surface, and cold currents of air blow above the mean surface of dry land. Under all conditions of air-motion the waters in contact with it are acted on, causing united action by the two cosmical agents.

Passing on from these dynamical actions, we come to the direct action of the sun on all the moisture of this earth, known by the name of evaporation. We recognise in this system one truth, uttered by Hugh MacMillan in his "Bible Teachings in Nature," p. 155, "All nature is one great system of mutual accommodation." Thus, "all the rivers run into the sea, yet the sea is not full; unto the place from whence the rivers came thither they return again." This is done by heat: the hotter it is the quicker the earth's surface dries; or, in other words, the greater the power of the sun the greater the evaporation from land and water and from vegetation. Under certain conditions the moisture thus drawn into the atmosphere falls again as dew. Under other conditions the moisture rises till it meets with a stratum of air cold enough to condense it into a rain-cloud. When this rain falls the sea and the land receive it, some runs back to the sea in mountain torrents, some percolates the soil where it falls, filling the earth with its supplies, eventually returning to the sea by surface or by subterranean channels.

These mutual exchanges are more or less active in the different zones: ruled everywhere by the presence or absence of the sun as a direct force upon moisture, and as an indirect force by its influence on air and water currents. If we accept the rainfall, under all its phases, as a cosmical force, in unison with the great dynamical actions of air and water, we have these two elements acting with and on dust in all its varied conditions, with all their varied modes of action, each mode being dependent directly or indirectly on the presence or absence of the sun.

The sun is then the mechanical lawgiver to this earth, realising the truth of the experiment exhibited to the Royal Society on the 7th April 1875, by Mr. Crooke, that "a mechanical power exists in radiant light and heat;" by this heat solids and liquids are evaporated into vapour; by cold, vapour may return to its normal condition. The winds, the water-currents, the tides, and the waves are kept in perpetual motion, and all dusts are more or less liable to the influence of these agents of the sun.

It is convenient here to divide this influence into three heads. First, as exercised on the surface of land and water; second, on subterranean; thirdly, in submarine material. If we know how the cosmical forces act now, we shall know how they must have acted from the beginning, and realise the great cause of the unbroken horizon in the construction of this earth.

Firstly, Our mountain tops are the first evidences of direct elemental influence; the sun dries them, cracks them, and exfoliates them according to their individual formations; the rainfall and the wind subtract all the *débris* capable of being moved by their relative powers. Water is lodged in crevices, and saturates portions here and there; the frost freezes such places, and the expansion of ice subtracts more material from the rock face. Every fragment that rolls down is divided into atoms of varied sizes; the heavy atoms roll further than the light ones, and hence we find at the foot of our mountains masses of large conglomerate, higher up conglomerate of gravels or brescia, and higher still conglomerates of fine material, all formed from the *débris* of masses which once constituted the mountain top, all cemented with the adhesive material predominating in the locality. Vast quantities of rock material, subtracted from the mountain side, rolls into water channels; when the rain fills them, every atom, correlative to the water force, is carried on by it, is broken up, and divided as it is forced on, and leaves in its divisions the boulder, the pebble, the gravel, and the sand.

On lower levels we see the tempests and the whirlwinds sweeping the dusts and the sands from the earth's surface; we see some of the results in the sand dunes, raised into great hills in America by long continued forces working in one direction, covering areas of cultivated lands as in Bermuda, overwhelming travellers in the sand deserts of Asia * and Africa, turning the day into night on the dried-up dusty plains of India. Raising in all regions, from the face of land

* "The atmospheric suction into the Terghâna hollow is so strong that it frequently draws in the heated air generated in the sandy deserts of Central Asia. . . . This wind (Gharm-sal, "hot blast") blows almost daily at Kokand, producing a darkness, from the air being loaded with fine dust."—*M. Tedchenke.* "An inexplicable dust, coming no one knows from where, falls like rain, . . . the dust is so dense that the sun's rays cannot penetrate it, and this sometimes continues seven or eight days."—*Danibeg.* "Geographical Magazine" for June 1876, note p. 150.

and water, all dusts correlative to the force, and dividing into the most minute dust the fragments subtracted on the route of the tiphoon or the hurricane. Under the same influences the waters are stirred to fury, the salt spray is driven in the air for many miles. We have seen a waterfall met by a wind-storm, and hurled back in an arch of prismatic spray, far over the mountain top, where it once formed a portion of a stream. Pillars of water are raised from sea and from lake by travelling whirlwinds, subtractions and divisions are in constant action somewhere; as the sun never ceases to shine, so his cosmical agents never cease to act.

There are results from these actions that may be called indirect results. Thus the moving of the forest leaves by the wind gives a greater influence to the sun; the movement of the ocean-surface exposes fresh surfaces to cold and warmth. Thus the effect of evaporation is increased, but this has its limit. M. Child Chaplin, in his beautiful work "Benediciti," 7th edition, p. 97, tells us that "a cube of air, measuring 20 yards each way, is capable of taking up no less than 252 lbs. of water before it reaches the point of saturation." This evaporating or attracting force of heat is computed to take from water and from land a supply of vapour that may give a rainfall equal in bulk "to 18,624 cubic imperial miles." There are arid regions that seldom receive any share of this vast supply. The average fall in England is about 28 inches. Brazil has counted 200 inches, and it is said that 605¼ have been registered in India. The rainfall in any quantity or in any shape, as dew, or hail, or snow, is a force wherever it falls; it deposits in dry land atoms evaporated from the waters, and drops upon the seas molecules subtracted from dry land.

We allow with Dr. Lardner that "matter is in fact indestructible," but, as far as human perception goes, as to solids, liquids, or gases, divisibility is unlimited. Newton told us that a soap-bubble, at its bursting point, was the 250,000th part of an inch in thickness. Ehrenberg discovered that 1000 infusoria might swim side by side through the eye of a needle. The food, and its division, of these living creatures, and the molecules of water that formed the soap-bubble, are as far beyond man's comprehension as the silicious coating of a blade of grass, formed from the moisture of the earth, or the many-coloured silicious coatings which glaze the feathers of the birds, or his own hair, rising to the surface from the moistures of the skin.

Matter of any sort, however fine it may be divided, belongs to the great family of dust. We recognise our relations in the Aurora Borealis, in the coloured vapours of the rainbow, in the fallen meteor, in the solution that return to us again as crystals, in the water-spring that leaves its solutions as sediments, in its basin or on its brink.

The long persistent action of elemental forces, in all their varied phases, direct and indirect, on homogeneous and heterogeneous dusts, have never been duly considered by our geological schools, and the results have frequently been assigned to causes, the very existence of which has been unknown. When we know that certain formations could never have existed without certain causes, we are authorised in accepting the formation as evidence of the cause. When we find a great mass of hard rock in an unstratified condition, we know at once, by the character of the rock, whether it was lodged where it is by forcible or quiet conditions. We know that there are quiet places in seas, lakes, and rivers; we know that solutions and atoms in suspension perpetually circulate into these quiet spots, and we know that the suspended matter subsides, and the solutions, returning to their normal molecular condition, do the same. We know that under the system of subtraction and division now at work on the surface of the earth, masses are broken up, and triturated into the smallest parts. Under this process the light materials are carried forward by river, stream, or ocean current, till they are wafted into quiet spots. All this light matter is more or less homogeneous; that which sinks to-day sinks into and amalgamates with the same soft yielding material which sank yesterday. As long as that area of water is without currents, so long will this homogeneous deposit remain unstratified. The condition proves the cause.

Taking the other condition, we know that no granular matter is formed or moved by quiet water. We see the angular rock masses fall into the flood; we trace the workings of the flood upon them, through the boulders, the pebbles, the shingle, the gravel, into the coarse and fine sands. The quantity of these depends upon the supply, on the force, and on the water-bed. If we find a great mass of fine sand heaped together after a flood, we know that the supply of silicious rock has been great, that force and trituration have brought it to this condition. We pass through all the other conditions with the same observation: if we find the rock masses still angular and unbroken, we know that the water-force was not equal to its destruction.

In many rivers, in the lakes, and on our sea-shores, after storms and floods, we see great collections of sands, gravels, pebbles, and shingle, all supplied from their respective materials, by their respective forces; all without stratification. We take these masses as evidence of the cause. Knowing the cause of unstratified formations, we reject the classification of the old unstratified rocks with igneous rocks, and bring them in as certain proofs of surface subtraction, of division, and of deposit by the direct or indirect natural forces, under the influence of their lawgiver, the sun.

The margin between surface and subterranean influences is so narrow, while some of their results are almost identical, that we go on to consider the next heading.

Secondly, The subterranean influence of water. We place under this heading all the rainfall which is not moved off by the ordinary surface drainage. It was once calculated in France that only one-third of the rainfall on land was carried by the rivers aboveground to the sea. Taking this literally, and excepting the measurement above given as representing the total rainfall, we have 12,416 imperial cubic miles of water as representing the subterranean supplies. But we cannot accept these figures as a measure of cosmical action. There are abrupt mountains from which nearly the whole rainfall is carried off by immediate gravitation, through little grooves and vast gorges. Again, a vast quantity of water, carried to the seas by rivers, has been subterranean water. To make this intelligible we must go up to the mountain top. Below the bare and worn rock-summits we find irregular lines of brescia and earthy matter, all fallen from above, and all resting on such slopes or resting-places as they can. The upper edge of these lines is generally very permeable, and accepts all the ordinary rain that rolls into it from the rock-face above. When the rain is heavy it overflows the edge, and is carried, by its own excavations, to lower levels. The water that percolates between the rock-face and the *débris*, is, or rather may become, the deepest water below the ordinary surface of the land. If there are no bars or undulations on the rock-face, and assuming it to be a primary formation, that formation may lead the water that entered at the hill-top to the bottom of the sea. If there are bars or obstructions on the face of the subterranean rock, the water that entered the edge of the *débris* is ponded back to find an outlet in a surface-spring.

These springs are very numerous, very copious, frequently indicating the subterranean water drainage, by bringing sources near to one another, while the surface formation may lead its water-shed in opposite directions.

Have we not evidence in the mountain rivers issuing from springs, and in the torrents rolling down the naked rocks, that both of these actions began with the beginning? On the torrent side we find, all down the course, fragments of the mountain. All down the course, even for hundreds of miles, we find boulders and pebbles formed from the same silicious or calcareous rocks, as may or may not now exist far above the torrent-bed; in places these mountain-remnants are scattered far and wide, while unused gorges, on the mountain side, tell that the water-shed, which once subtracted masses from their sides, has been long ago taken away from the mountain top. The ruin carried down by these old ravines is in the bosom of the plain. We come upon it now and then on high levels, sands, pebbles, and boulders, to tell us that, millions of years ago, these very hills sent down their supplies to the ocean retiring from their feet, exactly as the torrents carry on the same materials to increase the size of dry land to-day. It is the same with the great rivers issuing from sources. Marine formations can be traced to their issues, and from thence to the present sea-level. These rivers, all springing still from their original sources, have maintained their original courses, as long as primeval rocks mark out their valleys; but when they launch out upon the more level plains, beneath which thousands of feet of dusts are deposited, their waters spread to find out easier channels, and hence many of our great rivers now run on beds, far away from where they once ran, and join the sea by many new mouths: tides and river-floods keeping them open by their never resting forces, while river-floods and sea-tides perpetually build up the delta with dusts subtracted from the ocean and the dry land.

Following up the descending surfaces, on which the rain falls, we come upon the lower declivities of mountains and the tops of secondary hills. The rain that falls upon the first finds an easy access to the interior, except where the original rock crops out. Where broken rocks, in small or large masses, form the general surface, each rock fragment guides the water that flows upon it into subterranean rills. The rain which falls upon the secondary formations frequently finds an easy entrance through the cracks and crevices caused by the natural contraction of the mass when drying, or by the unavoidable subsidence of nearly all rock formations, excepting those which once formed the non-contracting ocean-bed. We have mentioned the cause of such subsidences in other places, but it is so connected with the subject before us, the force of subterranean water, that we will briefly explain it here.

Man has known for a long time that the ocean-bed is undulating. He knows now, by the labours of the "Challenger," that in many places it is very precipitous. He knows that the ocean once rested on the present mountain tops, and that the rock-foundation of the present dry land is as undulating and precipitous as the present water-bed. Excepting in places where the primeval rock crops up, the dry land is formed by fragments of those rocks, of the dusts of organisms, or of the two mixed together, and deposited by water on the ocean-bed. We have just shown that some subterranean waters must necessarily run along the face of these old rocks beneath the deposits on them. All moving water moves something away from the bed on which it moves, or it subtracts something from those masses with which it comes in contact. As the deposit resting on the rock is for ever gravitating downwards, it follows that it must for ever lose some of its lower atoms, whenever the water vein is capable of subtracting it. There are some strata in this earth which cohere together by chemical affinity, some by pressure; the latter are most likely to subside, because their adhesion is not strong, while the cause of their cohesion aids in their subsidence. Thus sand areas subside when the subterranean waters have sunk lower than usual, leaving the upper portions dry and unadhesive. Areas or masses that cohere with strong chemical adhesion, may be deprived of support for long periods, and remain during historical ages as vast subterranean cavities, evidences of internal adhesive strength. There are, or rather there have been, cavities of a similar nature, where an extra weight, supplied by the rainfall, has forced vast masses into the hollows below, fracturing mountain sides, interrupting the course of the subterranean waters that caused the subsidence, landslip, or earthquake, and altering the surface of the locality.

The undulating condition of the ocean-bed seems to affect the deposits that rest on it, or it may be that the permeable and impermeable strata have accidental planes of their own. Either fact may account for the difference in level of the water in wells, at no great distance from one another, for the water runs in mines and quarries at different depths, for the holding of the waters of Lake Michigan to a certain height, when they find their way out by permeable strata (see "Scribner's Monthly" for April 1876). On the same principles we find springs issuing in the beds of rivers as well as on the bottom of the sea. The latest scientific notice we have seen on the subject was in Hardwicke's "Science Gossip" of November 1875, where water is mentioned as rising to the surface from a depth of "790 feet," while another water-run "was struck at 950 feet."

With a tolerable regular rainfall on the earth, with every variety of reception of which the surface dusts are capable, it is not astonishing that we find a supply of subterranean water, varying in quantity, not only with the rainfall, but with the nature of the dusts which receive it and admit of its percolations. Thus in the arenaceous highlands of Central Africa, Livingstone found the water oozing out on long horizontal lines; it does the same in the red sandstones of Europe. Calcareous formations often have smaller holes, and discharge their waters by channels. On some of our sea-shores the chalk lands send out their springs in sheets or in frequent rills. The silicious rocks discharge their water-supplies through crevices or clefts of varied sizes. In artificial borings the waters rise in proportion to the pressure from their source. Whatever the force of any issue may be, it brings with it, in suspension or in solution, some of the material through which it passed in its subterranean journey; the microscope reveals its character, and our boilers retain it in tangible conditions. These solutions are prepared by the persistent trituration of percolating water, through the whole course of its progress in the salty earth. Every dissolved matter is divided from the subtracted atoms of a larger size, and these atoms are carried on all through the subterranean water-runs, in company with solutions, to form great unstratified masses as gault, in all places where the water is ponded back.

We shall meet with these formations in another place, but there are surface proofs in most regions familiar to all. We may mention the silicious sinter at the mouth of Iceland's Geyser, the calcareous crust at the hot springs of Carlsbad, and the carbonic acid gas that bubbles up in the cool Homburg fountains. Men have even satisfied their curiosity on these points by ascertaining that, if the same quantity of matters had been discharged in all geological time as is now discharging, several springs would have formed considerable mountains. All these formations are unstratified, though they may have lines in them caused by the occasional intrusion of foreign matter. As issues from warm springs, these ejections contain sodium, calcium, and other local heating causes. These constituents are evidence of this local cause, while the whole formation is, like other formations mentioned above, the certain proof of a subterranean water force, that subtracted atoms from the earth, through which it percolated, triturating and dividing them into the smallest particles, to cast them out on earth's surface again in altered conditions, or as solutions mixed with the spray or the stream, to form a new mass, or to mix with the common dusts of the vicinity.

Wherever the sun shines and moisture exists, there must be evaporation and rain; wherever there is rain, there must be surface or subterranean subtraction of dusts; both actions may take place on and in the same locality. Some of the natural results of these actions will be further discussed in our earthquake chapter; but we beg our readers to remember that a vast force of water is now, and has been at work ever since rain fell upon this earth, on and under its surface, with never-changing duties in both conditions. It has to renovate the earth, its life, its growth; to subtract matter from high, and remove it to lower places. It has to exert its wildest force to divide matter into sizes, adapted to all places, and to carry on the rocks, the boulders, the pebbles, the sand, the clays, the muds, the silts, and the solutions, as long as each is correlative to its force; then and there to hand it over, in each condition, to its own stern law of gravitation, all in unison, all in harmony; each element as an individual, and united as a trinity, in every situation, and in all conditions, attending to the ordinance—"Forsake ye not my law."

Thirdly, We have now reached the third division of our subject; our chief object is to draw attention to some of the direct and indirect influences of air and water, singly and combined, on the dusts of this earth. The results and the actions are visible and tangible to all; while to some they are so familiar, that they have ceased to attract any attention as actions of the great cosmical laws which have helped to bring the surface earth into its present condition. We feel the wind blow, and we see the waves raging; we see them discoloured with and full of matter, and we see some of that matter thrown up on the shores. The waves and the winds are doing now what they did before the birth of dust—subtracting matter from one place, and depositing it in another. It is of no consequence here from whence that matter first came, but the actions of the elements bring it from the bottom of the waters to the shores of dry land. We see the divisions to which this matter has been made liable; the pebbles, the sands, the shells, the clays, and the muds are all deposited in order; the light materials cannot rest in strongly moving winds, waves, or currents, and the pebbles cannot be moved by still waters, or by no winds.

When the wind blows from the shore the tides are slow on the flood, and fast on the ebb; when the wind blows on the shore the flood-tide rises higher, and the ebb retires slower. In the latter case the sea is rough, in the former it is smooth; both actions affect the quantity and quality of the matter lodged upon the shore; the quiet tides may waft entire shells along, while rough waters may reduce them to paste, or ooze, as it is called by the reports from the "Challenger;" eddies and back-waters make banks. It is said that the action of waves is not felt beyond a reasonable depth; those off the Cape of Good Hope or Terra del Fuego act deeper than those of the Red Sea or the Baltic; but wherever their influence reaches the bottom, it is occupied in the everlasting labour of subtraction and division. Every sea-shore, all round the dry land, gives evidence of the labour; every valley, and every primary mountain-top, from the highest pinnacle, through thousands of miles of dry land, down through ancient river-beds, and in the present deltas, all the earth, in fact, is evidence of deposit by wind, by salt or by fresh water. The character of the deposit is the proof of the force that left it; the construction of the deposit is evidence of the material that made it.

Ocean currents, tides, waves, typhoons, tornadoes, hurricanes, gales, the summer breeze, and the soothing calm, have all their separate and distinct influences on us dusts. Man has not taken the trouble to look into the intricate subject; he will not comprehend that areas of this surface earth are and have been unsupported, in consequence of the constant subtraction of material from below; he will not understand how the sea has sunk to its present level, by constant subtraction from its own bed. These two subjects are treated of in separate chapters; all we need say here is, that the present ocean depth is proof of the action on its bed, and the subsidence of land or an earthquake are proofs of the action in the earth.

Have we said enough to prove that dust began his subtraction and division as soon as there were figures to work upon? Have we shown that the sun is the ostensible lawgiver to this earth? Its very motion round the sun is possibly guided by its light. That motion gives the summer and winter to the zones; man may learn by his own experience what nature does in the different seasons. He multiplies and adds in the spring, in the summer he subtracts, and divides in the autumn and the winter. Nature does the same to-day; she has done it since the law ruled the elements. Ever since nature produced the beautiful and the plain, their dusts have gone on adding to the earth; ever since their autumn time came on, they have endured subtraction and division. The richer nature's produce is, the more satisfied man becomes; the more plentiful the supply of summer, the greater the subtraction and the division of winter. Man could not be as he is without the elemental actions. The dry land and the ocean bed owe their present conditions to the same causes.

These causes and their results can be traced all through the sedimentary dusts of this earth. They exist all over the bed of the waters; the arrangements for new dusts are making hourly with the same care as millions of years ago. There is no break in the harmony of the law, though there are breaks in the dusts acted on, and breaks in the manner of their treatment; still the work goes on for ever, still the elements must subtract and divide, and still the dusts must for ever be obedient to the law.

When we began this chapter we had a chaotic heap of dust before us—

> "Pure crystals had been made by fire;
> Fire made the mountains higher."

New theories sprung from every pen; the subject of denudation was completely muddled. We wrote page after page of argument without reaching our own biography. It then struck us that we could not do better than follow the example of our illustrious ancestor. All the arguments were thrown to the winds; we endeavoured to copy the brevity of our original preceptors; we tried to convert old theories into new systems. We have attempted a faint outline of cosmical action.

If our sketch shows how certain results follow action, how action depends on the law, and how stable that law must be, it will be easy for any lover of physical nature to fill in the lights and the shades we have indicated. He will recognise in the plenitude of his reason, that nature has provided the beautiful, the ugly, the sweet, the sour, the hot, the cold, the salts for life and death; that in the time allotted by the Creator, all these growths and lives are ended, to be given back for re-assortment as dusts by the never-resting actions of air and water. If he gets as far as this, he will see the truth of our biography, and understand that, as silicious matter is indestructible, so our position is unassailable. The subject is immense, grand, and beautiful. Men are alarmed at the fury of the wind or ocean; they avoid the thunderstorm and the rain deluge; they die beneath the frost and snow; they live in the sunshine, the shower, and the dew. All these changes, in all their infinite varieties, are due to the absence or presence of the sun. To his controlling powers we owe our cycles, our years, seasons, days, nights, mornings, and evenings —our hours, minutes, and seconds. At all times and seasons the cosmical elements are and have been obedient to that wondrous rule of light and heat. As long as the Creator permits the sun to shine upon this earth, so long must the elements of this earth do their duty on it; so long must our cosmical trinity subtract from what has been, divide it into what is, and reconstruct that which will be.

CHAPTER VIII.

THE PHYSICAL EDUCATION OF DUST.—MOUNTAINS.

"The strata of the entire cretaceous system exhibiting a gradually deepening sea bottom."—C. E. DE RANCE, "Geological Magazine," No. 120, June 1874.

THERE are certain dynamical laws to which we dusts must conform if we wish to retain our positions in cosmical transactions. In our trinity of earth, air, and water, the two last are active, the first is a passive element; it is at present composed of countless materials; we dusts are types of many. Each and all of us accept the attentions of the active elements, but no two of us have the same mode of doing so. As their attentions are for ever changing their expressions, it follows that, individually and collectively, the dusts undergo never-ending changes and movements.

The catalogue of materials that have from time to time been subjected to the attentions of the water or the atmosphere, are strictly preserved in the heights above, and in the depths below the waters; the whole formation is the result of the physical education of dust. We shall endeavour to confine ourselves to the actual construction of mountains in this chapter, so that it will be well to have a definite idea of what a mountain is.

There are degrees of comparison all through nature. A mole-hill is a mountain to a worm; an ant-hill is a mountain to a beetle; Greenwich Hill is a mountain to a boy; and the Matterhorn is a mountain to the members of the Alpine Club. All in turn climb up each, with a strong probability of coming down again. Any decided rise of cosmical matter, above the ordinary level of the locality, is a mountain to suit our purpose. All our mountains are composed of cosmical matter. Dust in some shape or another is present in every mountain. We have a mass before us, composed of visible tangible material. The questions are, How came the dusts there? and why do they rise above the ordinary level of the locality? It would be easy to answer these questions at once, but the clouds that cling to the mountain brow have thrown a haze over attempts at clearing up their origin. An encyclopædia has pointed out that all attempts to generalise on the construction of mountains have failed. There must be some reason for this; so that before recounting the physical education of our ancestor, it will be as well to wait till we can clear off some of the haze, and the long, long lines of clouds above our heads.

Of all the authorities we have ever rested on, Sir Charles Lyell has described mountain formation most accurately in his description of the sand ripples on the sea-shore. Atoms are impelled upwards till they form a ridge—an exact miniature mountain range is recorded; but Sir Charles did not carry out the principle to its legitimate limit. Again, he saw similar formations in his North American travels. Writing of the islands in the State of New York, in vol. ii., p. 109, he says, "This great beach or bank forms a line of spits and low islands. . . . They are all narrow and long, and when above the reach of the surf they are covered by a labyrinth of hillocks of sand, imitating almost all the variety of form which snow-drifts present after a storm." At page 103 he tells us of the parallel ridges between lakes Ontario and Simcoe. The first ridge is steep towards the lake, 20 to 30 feet high; its base is of clay, its top is sandy; it is 108 feet above the level of Ontario. The second ridge is 208 feet above the lake, and 50 to 70 feet above the ground on either side; there are boulders at its feet, and some at its top; the distance between these ridges was 2½ miles. The third ridge was 5 miles from the lake, with a slope of only 10 feet. There are eleven traceable ridges "which cover everywhere the subjacent silurian rocks." After a rise of about 680 feet on the Ontario slope, there is a descent of 282 feet for 42 miles to Lake Simcoe. On this slope are several ridges "at levels precisely corresponding to those which I saw on the south side." All these ridges are said to correspond with those on the uplands of the Ottawa River, and, says Sir Charles, "I consider the ridges marks of ancient water levels, between Toronto and Lake Simcoe, as referable to ancient beaches and lines of cliffs formed on the margins of channels of the sea. . . . Others, including some of the loftiest ridges, as having originated in banks or bars of sand, formed, not at the extreme edge of a body of water, but at some distance from the shore, in proportion as the waters obtained a shallowness by the upheaval of the land." Sir Charles did not know that the shallowness was caused by the retiring of the waters. He tells us, "It is well known that on many shelving coasts the breakers give rise to banks of sand at no great distance from the beach." We shall see the legitimate end of these actions presently. Sir Charles Lyell had only one idea of mountain elevation—that idea was the cloud that clung to his mountain formation, obscuring his understanding, while his eyes perceived the action of the active forces on the passive dust, building up mountains everwhere.

Sir Charles mixes truth with fiction so closely that it is difficult to see the light. When writing of the fractures and fissures of the Appalachian Mountains, he tells us that "these changes have consisted of the denuding operations of the sea, which probably took place, in great part at least, during those movements of elevation which, after the period of the new red sandstone, uplifted the Appalachian strata to their present level above the ocean." The denuding system only is required to produce the changes; there was no occasion for any uplifting. Sir Charles goes on, "It was truly remarked that during the process of congelation and contraction the incumbent strata, or those first solidified, would sink and accommodate themselves to a narrower area, namely, the circumference of a spheroid of smaller diameter, and, according to their different degrees of pliability or hardness, the beds would be bent or broken." Sir Charles tells us it happened from "the supposed original fluid nucleus of the planet, it being assumed that the earth passed gradually from a state of fusion by heat to a solid condition." Having supposed and assumed this state of things, Sir Charles blows away his clouds by telling us—"We have only to substitute the partial liquefaction of the interior of the earth at moderate depth for the primitive fusion of the entire incandescent nucleus, and to suppose that each local development of subterranean heat was followed by refrigeration, and we shall discover a cause fully adequate to produce the fracture, plication, and lateral pressure of rocks, at as many successive periods of the past, as the facts now established in geology require."

It is curious to follow the footsteps of those who have followed Sir Charles up his cloud-covered mountain. We will take a step upon the path taken by Mary Somerville in her "Physical Geography;" strangely enough, it makes a distinction between Sir Charles and our soundest geologists. She tells us that "the increase of temperature with the depth below the surface of the earth, and the tremendous desolation hurled over wide regions by numerous fire-breathing mountains, show that man is removed but a few miles from immense lakes or seas of liquid fire." We remark in passing that the probabilities of Sir Charles are now certainties; but Mrs. Somerville is very honest; she tells us a few pages on that "there is no proof within the historical period that any entire mountain chain has ever been raised at once, although it is generally *admitted by our soundest geologists* that such took place at remoter periods, and that by this means the great mountain chains of our globe have attained their present position." She then tells us that a *contrary opinion* is advocated by *Sir Charles Lyell:* "elevation has been produced by a long-continued and reiterated succession of internal convulsions, with intervals of repose." These are all clouds that will vanish when the wind blows.

No sooner are they gone than another dense mist is wafted over the scene, till we almost think the point we strive to climb to is itself a cloud. Mrs. Somerville tells us that "fossil shells of different geological periods are found at various elevations, which shows that many upheavings and subsidences have taken place in the chain of the Andes." The clear mathematical understanding of the lady is here misguided by Mr. Darwin, "who supposes that the whole range (of carboniferous limestone), after twice subsiding some thousand feet, was brought up by a slow movement in mass during the eocene period, after which it sunk down once more several hundred feet, to be again lifted up to its present level by a slow and often interrupted motion." Mrs. Somerville is a favourite authoress; we seldom find a protracted rest upon her volumes, but we do wish that she had climbed her mountains without a guide.

Cloud after cloud still rises up the mountain-side to impede our view; lakes, rivers, swamps, the plains, the forests, all contribute their fleeting clouds, and as they flit through deep ravine, as they sweep along the scarp, or slowly climb the half-hidden brow, we begin to be impatient, and say that we cannot reach our summit to-day; our silent guide signs patience, waving his hand to tell us that they are rapidly flitting away. As we look at them, they gather in waving, still condensing masses; still rising, and forming a straight line resting on the mountain-top. As nature gathers her moistures together, so Henry Woodward has gathered for us some of those misty mountain formations, which we must see through before we can find our way; they are in No. 114 "Geological Magazine" for December 1873. We are told that "the question of the formation of mountain chains has of late occupied the consideration of many of our ablest and most profound physical geologists." As the cloud-line along the mountain-top is the result of one cause, so "all the corrugations of the earth's surface . . . are to be regarded as the effects of one and the same cause."

If Mr. Woodward had stopped there, nature might sooner or later have asserted her rights in the inquiring mind of man; but he leads his audience back to his own cause: "whether we regard the earth as an oblate spheroid, perfectly solid throughout, or as having a more or less thick crust and a fluid interior, we are justified in considering it as suffering from cooling by radiation, and contracting in a more or less degree, from a time long antecedent to the formation of the very oldest metamorphic or sedimentary deposits with which we are acquainted." We cannot waste time by asking why the solid body should be hot, or why the earth should suffer; there is no surmise, no probability now, all is certain. Mr. Woodward tells us, "that through the unequal contraction of the earth's crust, by which the great continental areas were originally elevated as vast anticlinals above the general ocean, the first preliminary stage necessary for the commencement of mountain formation would be accomplished." We are not told what the continents were formed of, or whether the vast anticlinals were cracked and fissured, but Mr. Woodward clothes them with sediment "resulting from meteoric action" to the depth of 10,000, 20,000, or even 40,000 feet in thickness." Having done this he asks, "Why does the yielding to horizontal pressure take place along these lines of deposit in preference to any other?" We remark, in passing, that the fact of horizontal pressure is not proved. Mr. Woodward finds an answer to his question. Professor Joseph le Conte suggests that the answer is to be found in the theory of the aqueo-igneos fusion of deeply buried sediments.

Mr. Woodward found he had a heavy work on hand. "Scrope, Babbage, and afterwards Sir John Herschell," are called in to show that "the accumulation of sediment necessarily produces a rise of the geo-isotherms, and an invasion of the sediments by the interior heat of the earth." Here we have fiction and truth in a tangible shape. We (dusts) know nothing of interior heat, excepting that which we produce, with which we make our volcanic mountains and hot springs. Mr. Woodward having made one false step by introducing the invasion by interior heat, is obliged to show how it acts on the areas that had already began their mountain formations—that had cooled and contracted theoretically. He thinks that "even the former moderate temperature, long continued in the presence of the included water of the sediments, would be sufficient to produce incipient change—at least segregation, if not metamorphism," and then, having settled the point that the temperature "of sediments, 40,000 feet thick . . . must be nearly 800° Fahrenheit," he tells us that "such a temperature is certainly sufficient to produce not only metamorphism, but aqueo-igneous pastiness, or even complete aqueo-igneous fusion."

We cannot stop here to ask Mr. Woodward how it was that water was still included in the sediments, where the heat was, as he supposed, sufficient to produce metamorphism; we should be only producing more vapour, and greater obscurity, just as our atmosphere shows symptoms of clearing, for again Mr. Woodward hits off the truth—"with a small quantity of alkali in the included water of such sediments, all these changes would take place at a much lower temperature." Mr. Woodward is so correct on this point, that we ask in passing—Why, if a little alkali in the water could cause such a result, a larger quantity of alkali should not cause actual fusion of the rocks? We cannot answer that question till we have constructed our mountain; if we lose our clue in the pathless wastes, we should never find it again.

We have now to connect the theory before us. It is evident that if there was a melting of the sediments at a depth of 40,000 feet, there would be some pressure, so Mr. Woodward tells us that "subsidence probably continues during this process." If the process exists, he might have used certainly instead of probably; but he gets more confident as he goes on—"Finally this softening determines a line of yielding to horizontal pressure, and a consequent upswelling of the line into a chain. Thus are accounted for, first, the subsidence, then the subsequent upheaval, and also the metamorphism of the lower strata so universal in great mountain chains." We shall comprehend sooner or later that the metamorphism, the upheaval, the subsidence, the pressure, and the softening, have no connection with melted sediments in the history of mountain formation. Mr. Woodward, however, concludes his theory or his address, so far as we are at present concerned, with, "Thus, the phenomena of plication and of slaty cleavage, demonstrate a crushing together horizontally, and an upswelling of the whole mass of sediments . . . sufficient to account for the elevation of the greatest mountain chains in the world." This is very similar to what Sir Charles Lyell told us.

We had almost determined to begin our ascent here, but there are two theories that must not be passed over, because they have both attracted some attention. In the "Geological Magazine," No. 115, Captain F. W. Hutton tells us, in reference to the contraction theory of the

Rev. O. Fisher, that by it "utter confusion would reign in stratigraphical geology." The Rev. O. Fisher, in "Geological Magazine," No. 116, remarking on the deposition theory of Captain Hutton, says, "I should like to see a diagram showing a range of mountains formed on Captain Hutton's theory." There are those who, in their mountain wanderings, have seen patches of vapour floating upwards from the gorges on the opposite sides of ridges: the silvery vapour is very beautiful. We stop to gaze on the wondrous evolutions of each mass; we begin to think that, as they must inevitably meet on the ridge, they will envelope the scenery, and hide the view; but as each mass rises from its gorge, they meet, they kiss, and then, instead of expanding, both masses rise, revolving in vertical circles, till, like the *mares' tails* in the summer sky, they mix with and are lost in the eternal firmament around them.

We believe that Mr. Woodward and his school have built up their mountain ranges by the assistance of an internal self-existing fire of which they know nothing. Illustrious painters have given clothing and feathered wings to their cherubs and their angels: they do not know if feathers or clothing are to be found in the heavens. Our geologists do not know if fuel or fire are to be found in the earth below; but as long as human imaginations sway the pen or the pencil, so long will the fires burn and the feathers grow. We are led back by these thoughts to Plato, who makes Socrates tell Gorgias that the "Rhetorician, therefore, does not profess to teach courts of justice and other public assemblies respecting things just and unjust, but only to produce belief."

We dusts cannot find our way through the fire world; but we find in "Chambers's Encyclopædia" a remark that leads us back to our own sign-post—"To suppose (said Professor Rogers) that mountains are elevated by a wedge-like intrusion of melted matter, is to give to a fluid functions incompatible with its dynamic properties. So also the supposition, that the igneous rocks were intruded as solid wedges, separating and lifting the crust, is opposed to the fact that no apparent abrasion, but generally the closest adhesion, exists at the line of contact." Plato thought that the believers were worse than the teachers of error. We beg here to remind our readers that all the mountain formations we have touched upon are only theoretical, while the biography we are detailing is founded on those laws of nature which are now, and for ever have been, in action. Previous chapters have taught us how the cosmical trinity brought about the birth and the multiplication of dust. We have shown results under the doctrine of wisdom, "forsake ye not my law;" we have now to consider the education of dust in other seasons, when the gentle handmaid gave place to her rough brother, and when the summer ripple of the waters was changed into the raging billow. The scene seems full of confusion, we imagine ruin and destruction; but all is done by the law. As the muscles of man are developed in his gymnasium, so the girders of this earth were developed by dust, under the tuition of wind and water in the boundless gymnasium of this round globe.

We have to begin at the beginning, we have to comprehend the character of the professors before we can understand the nature of their doctrines. The wind must be looked at in every condition of force, from the fresh breeze to the hurricane, from the little whirl that licks up the dusts of our streets to the great whirlwind that severs the mountain top, that lifts up the ocean, that buries the caravan, and that even now eclipses the mid-day sun. Different localities have different names for these blustering actions of nature: the tornado, typhoon, simoon, monsoon, storm, and hurricane all come under one head, as our Professor Wind, brother to the gentle handmaid Air, and as sooner or later her successor in the education of the dusts of this earth. We have to look upon the water not only as affected by all the varied actions of the wind, and thus aiding in the education of dust, but as having special classes in his own vast gymnasium. In every class, separate or combined, under the instruction of water, or under the influence of wind, dust had to undergo his physical education. Long before dry land appeared, nature was preparing its solid foundation; that foundation is here now, and on that foundation the waters have been at work for untold millions of years. There are two actions in that work, one destroys, the other constructs. We cannot explain these actions better than by quoting a few passages from the report of Captain Nares, H.M.S. "Challenger," to Admiral Richards, late Hydrographer of the Admiralty, dated 18th January 1873: "At the depth of 2025 fathoms on the east side of the rise, the sounding-rod was filled with decomposed rock, showing a rocky foundation; the dredge, however, brought up ooze." Here we have examples of construction and destruction close to one another. "The rocky nature of the bottom, and the lowering of the temperature usual at that depth, would indicate a considerable movement of the lower stratum of water. At this position the dredge brought up a quantity of dead hard coral . . . with no mud." Thus the forces of the water permitted no sediment, but allowed hard material to drift over the rocky bottom. "The several deep soundings taken in the neighbourhood of Bermuda prove it to be a solitary peak, rising abruptly from a base of only 120 miles in diameter." This shows that mountains are formed on the sea-bed. "The stream rushing past us like a mill race," tells of the vast power of ocean currents.

From another report, dated 15th September 1873, we gather that at the Cape de Verde Islands, "the bottom water turned to run north more than half-an-hour earlier than the surface, and ran six and a quarter hours—a regular tidal interval," so that the atoms of the material held in suspension or solution may be conveyed to different places. "It is remarkable that the temperature at 80 fathoms, the depth at which the coral grows, is the same as that of the Mediterranean coral banks, viz., 52°; showing that water life requires similar temperature in various places.

In a report dated 15th December 1873, we find that in Simon's Bay "the current usually circles round from Cape Agulhas to Cape Point; on this occasion, while the water was gradually cooling, a current was circling round the bay in the opposite direction," telling us that currents can be altered by heat, by cold, or other influences.

"We find in the abstract of Captain Nares' deep soundings, that the nature of the bottom does not depend on depth: 1800 fathoms gives mud, 325 hard ground, 2125 sand and mud, 2025 rock, 2435 globegirina ooze, 3025 red clay, 390 coral mud, 435 coral and shells, 175 sand, 1370 sand, 51 rock, 83 stones and gravel, 1775 rock, 2650 ooze, 750 rock, 2675 ooze, 820 rock, 2150 ooze, 500 mud, 32 sand and coral, 1600 mud, 1000 shells, 2025 globegirina ooze, and 1100 rock. Every one of these quotations tell us not only of the materials placed at the disposal of the water, but each discloses the character of the water on the locality, to which we shall refer presently.

Under the influence of wind and water, the ocean bed has acquired the condition depicted by Captain Nares. The influences which have produced this uneven bed have been going on for ever. Before the productions of land and water gave materials to build with, the bed of the waters alone supplied them; the formations of those days consequently assumed the character of the materials moved by the waters. We find on mountain top, in the mountain interior, in the schists, in the granites, the gneiss, syenite, and many other rocks of the present time, above and below the sea level, the types of the only material available when dust began his physical education. All authorities consent to call these rocks primary; they belong to the so-called azoic epoch, and the illegibility of organic remains in these rocks gives a colour of truth to the nomenclature. The structure of these rocks is, however, so variable, the remains of organisms are so illegible, that no line can be drawn between the azoic and the palæozoic epochs. The flint nodule that has formed beneath the chalk is in itself an azoic mass; but it belonged at one time to a living organism; the silicious matter which constitutes so large a portion of these primary rocks is a movable, percolating substance, so that it is not impossible that the silicious matter of these so-called primary rocks may have at one time belonged to organisms which used silex for their clothing and their houses, as the diatom and the grass now do.

We have shown in the birth of dust how two long epochs of uncounted time worked up the water-beds to form the first dry land. Sir Charles Lyell has told us how the waves leave the sand ripples and the larger ridges behind them. As the waters do these things now, so they did then in the third day of creation, and as Captain Nares finds the sea-bed now, so was it in those long-forgotten days.

There was no hesitation in the wind when he began to educate dust, there was no disobedience in dust when he entered the gymnasium. Action became involuntary; he hopped, he jumped, he flew, he danced in circles small and vast, he mixed with unknown associates, he was deposited here to-day, and there to-morrow, his heavier comrades paused at the bottoms of the slopes, the lightest only stopped when the professor himself was out of breath with his exertions, and so, as Sir Charles Lyell found light sand on the clay spits of America, the lightest dusts took up the highest stations in their cosmical gymnasium.

We have shown in the multiplication and addition of our ancestor how soon his faculties were required to act. We pointed out that wisdom never allowed her servants to rest; there was always something to be done, and some one to do it. Thus, as creation went on, the winds had more to do, more pupils to attend to, still the same education went on; dust was constantly ushered into the arena, and as constantly left upon high places, heaped together in vast masses, shunted into little drifts, or deposited in the waters for further instruction there.

The discretion of the two professors was wonderful, scholars of all gifts, of all characters, and all abilities were placed under their care; they were mixed up in the fiercest strifes of elemental action; their nature, their capability, was tried to the utmost; the rough were smoothed down, the heavy were in one class, the light in another, and as, in the depth of the Atlantic, the "Challenger" discovered the light shells of foraminifera on the higher spots, and their clay on the lower, so, all through the physical education of dust, the natural professors have been careful to distinguish the characters of those entrusted to them. Thus, as Sir Charles Lyell saw in America ("Travels in North America," vol. ii. p. 176), "above the granite, clay, slate, quartzite, and Silurian formations of Nova Scotia, there occur strata referable to the carboniferous group occupying very extensive tracts, and resting unconformably on rocks of the older series." This unconformable condition shows that the present irregular sea-bed existed when these formations were deposited upon them; and we see that under varied forces of wind and water, with varied materials at their disposal, such a result was unavoidable, while the law was not forsaken.

Under the laws laid down by wisdom, and adopted by the two physical professors for their separate and for their united classes, the material entrusted to their care became developed in certain places, just as muscle becomes developed in the human frame by action. Before organisms were created, the winds and the waters gathered the primeval silicious matter into sediments and drifts; as Sir Charles Lyell found the light sand over the clay, so the lightest materials were worked to the highest points as we find them in the gneiss and syenite of our mountain tops, while the coarser materials were developed in the lower extremities; the whole resting on the solid foundation of this globe. As we see the mountains rising from the sea-bottom now, so mountains were formed upon the sea-bed at all times. As the education of dust went on, so the physical classes altered their characters. Silicious matter, mixed with vegetation, formed the second mountain ranges; upon these were deposited masses of vegetable, and as life was multiplied, the limestone formed from the remains of living organisms was heaped up by the waters, and gathered by the winds, often to rest on the flanks of the silicious buttress heaped up before them by the same forces. As the waters arranged their own classes, so we find the gneiss, the syenite, the granites, and the basalts contiguous to the formations from organic dusts.

Man has traced many of these dust deposits, he has placed the silicious gneissic and granitoid schists in the azoic epoch; we find these at all heights, and on the sea-bottom. Nature links her formations so close together, that they seem to casual observers as mere repetitions; in following on our clue we may also seem to repeat, but there are in our history and in nature classes that require the aid of the microscope. We beg attention to these classes. We cannot go through the whole series here, but we wish to show how materials of varied epochs may come together during the physical tuition of the dusts. Professor T. Sterry Hunt, in No. 114, "Geological Magazine," p. 562, tells us that in 1827 Dr. Bigsby "found resting directly upon the ancient gneiss a nearly horizontal dark-coloured conchiferous limestone," having sometimes at its base a calcareous conglomerate; he also found a "slaty series composed of shale and grey wacke, occasionally passing into a brown limestone, and alternating with a calcareous conglomerate in beds, some of them charged with fossils." These mixtures of matter resulting from the original deposits of dust, or from the destruction, removal, and redeposit of original deposits, belong to the details of our education. We have touched upon the subject to show that, in the entire depth of dust deposits resting on the "ancient gneiss," we never find a long defined horizon of one material; so that we go on with the arrangements that the Geological Schools have placed before us, on the understanding that, although chalk, clay, sand, slate, and granite may extend in horizontal lines for long distances, yet their foundations may be laid on undulating beds, and this undulating character is of necessity imposed upon the surface.

The palæozoic or ancient life epoch succeeds the azoic. Has not science been premature here—vegetation came before life; it is plentifully mixed with the azoic zones, and should have had an epoch to itself; it is embraced in the shales, slates, and coal-measures of this epoch, but as they form deposits separate from the silicious schists, the conglomerates, the sandstones, and the limestones, they ought to have been separated in the index formed by man? We now come to the mesozoic, or middle life epoch, including the triassic, oolitic, and cretaceous system—all containing types of organic life; while, as shown in our heading to this chapter, the entire cretaceous system exhibits a gradually deepening sea-bottom. We have already shown that this sinking of the sea-bed is a result of natural laws, and while the deposits of all created forms have been laid down upon its bed for millions of years, that bed has never forgotten, up to the present moment, to offer upon shores of dry land the purest sacrifices of its silicious sands.

Under the double labour of excavation and deposit, the next epoch, called the cainozoic or recent life, found high lands that had once been under water; they had furnished the dusts of living and growing organisms, mixed with their own torn breasts to form the wide and still expanding plains, upon which the present systems are up to this moment employed in forming their groups or classes under the tuition of our grand professors.

That which is done to-day has been done since the birth of dust. We see his physical education going on in the mighty waves of the ocean, in its great arteries, its tides, its eddies, and its whirlpools; we see the banks, the ridges, and the sand-ripples forming every moment. We see the winds taking up the dusts from the surface of the earth, and we find the drift and the sand dunes. All our present mountain tops were deposited by the same forces, all the different materials, according to their several epochs, were more or less liable to the system of education we have so imperfectly described, and as the waters have sunk in reciprocity with their structures, so, of necessity, the dusts have been left behind to assume the condition which we see.

Have we sufficiently cleared off the clouds from the mountain brow? Have we said enough for others to see nature as she is? Are we in a position to reply to the two questions in the early part of this chapter,— How came the dusts there? why do they rise above the ordinary level of the locality? If we have said enough, the simple answers to these questions will be sufficient. If we have left any one behind in the fog, we ask him to follow us into the next chapter. Dust, like man, has gone up the hill to come down again. The mountains, as we built them, are not like the mountains that we see. We were millions of years in their construction, millions of years have brought them to what they are. The footsteps of nature are very slow, her paths are very intricate, but she has left guides at every corner; the mountain stands up conspicuous as the great stratified sign-post of ocean's highway. They are found all round the world, from the Himalayas to the Beacon Hill on Salisbury Plain; from the Arctic to the Antarctic regions of all sizes, and of varied material, all dust.

Dust came there because he was obedient to the laws, he rose above the ordinary level because his preceptors did not forsake the laws, they taught to suit the genius of the pupil, and they left him as examples of discipline. Nature never rests; no sooner had dust developed his physical education to the utmost, than, like the human mountain climber, he was called on to come down again; his water preceptor had retired from the scene, dust after dust rolled back to his bosom, till Mr. Rance finds out the inevitable result of the laws—"The strata of the entire cretaceous system exhibiting a gradual deepening of the sea-bottom." We ask Mr. Rance and others to look at all the systems of each geological epoch, they will find that all tell the same tale. This gradual retiring of the waters has, therefore, left the mountains of dust gathered by the winds and the waves to serve as girders of this earth, as the buttresses of the dry land, and to be, as long as they endure, legible sign-posts on ocean's great highway. We must loiter a moment on our mountain top; fogs will rise again. We have pointed out a new path, we ask others to try it; we do not wish to lead them into difficulties, but before they try our path, or before they object to it, we wish them to find out if dust is, if winds blow, if waters move; if they cannot discover these points, we advise them not to walk upon our path; if they can see these points, we still hold out our little clue, we still follow nature's laws, we still invite those who can see to follow us into the sea-level.

CHAPTER IX.

THE SEA-LEVEL.

"He gathereth the waters of the sea together."

UNDER the guidance of Captains Nares and Thomson, on the deep-sea soundings of the "Challenger," with a little other assistance, we are now in a position to re-open the great cosmical problem of the sea-level. How did it come to be where it is? It is clear that all rocks formed at the bottom of the sea, and which are now dry land, "must have gained their present situation, either by the sinking of the sea-level, or by the uplifting of the sea-bottom. . . . If the mountains had been laid dry solely by the sinking of the sea, it is difficult to understand what can have become of a shell of water ten or twenty thousand feet deep, enveloping the whole globe."—*Juke's "Manual of Geology,"* 1857.

Our London Geological School has avoided the difficulty by adopting the uplifting theory—and thus accepting the present sea-level as the level of all time, without any knowledge of the depth of the sea in the beginning.

If we examine what the "Challenger" has proved to be doing now under certain laws, we shall be able to show that these laws must have produced some sinking of the sea-level, while there are no laws and no agents for the upheaval of mountains. We give a modern view of mountain formation, from the address of Mr. Henry Woodward, as published in the "Geological Magazine" for December 1873. He embraces the names of many scientific gentlemen, and comes to the conclusion, "that all the phenomena of corrugation on the earth's surface . . . are to be regarded as effects of one and the same cause." It will be seen presently that two causes are given. We will place these causes fairly before the reader, we will briefly examine each section on its own merits, and then compare this mountain formation with the doctrines of other geologists.

In selecting paragraphs for quotations, we must apologise for not giving the whole; we only use that which is applicable to the subject, and hope that, in doing so, we do not lose the meaning of the authors. For the sake of future reference we prefix a number to each quotation:—

No. 1.—"We are justified in considering it (this earth) as suffering from cooling by radiation, and contracting in a more or less degree from a time long antecedent to the formation of the very oldest metamorphic or sedimentary deposits."

No. 2.—"In a heterogeneous earth, thus cooling, *areas of greater conductivity* would cool more rapidly, and therefore *contract more rapidly*, in a radial direction. . . . The process of cooling through a stratum of water, would go on far more rapidly than through a stratum of any rocky material."

No. 3.—"Thus through the unequal contraction of the earth's crust, by which the great continental areas were originally elevated as vast anticlinals above the general ocean, the first preliminary stage for the commencement of mountain formation would be accomplished."

No. 4.—" Mountain chains are composed of enormous masses of sediment . . . even 40,000 feet in thickness. How have these vast masses been elevated . . . and why does the yielding to horizontal pressure take place along these lines of deposit in preference to any other? Professor Joseph le Conte suggests that the answer is to be found in the theory of the aqueo-igneous fusion of deeply buried sediments."

No. 5.—" The accumulation of sediment produces a rise of the Geo-isotherms, and an invasion of the sediment by the interior heat of the earth. Taking the increase of interior heat at 1° for every 58 feet . . . sediments 40,000 feet thick . . . must be nearly 800° Fahr. . . . Such a temperature is sufficient to produce aqueo-igneous fusion."

No. 6.—" With a small quantity of alkali in the included water of such sediments, all these changes would take place at a much lower temperature."

No. 7.—"This softening determines a line of yielding to horizontal pressure, and a consequent upswelling of the line into a chain."

No. 8.—"If we examine carefully any mountain range, we shall find that it is made up of masses of immensely thick sediments, . . . folded, crumpled, crushed, fissured, and faulted, . . . whilst the intimate structure of the rock has been entirely altered by having undergone *slaty cleavage,* produced by powerful pressure, perpendicular to the planes of cleavage."

No. 9.—"Suppose that a mass of sediment, 10,000 feet thick, subjected to horizontal pressure . . . sufficient to develop well-marked cleavage structure; a breadth of two and a-half miles would be crushed into one mile, and 10,000 feet in thickness would be swelled to 25,000 feet, making an actual elevation of the surface of 15,000 feet."

No. 10.—"Slaty cleavage proves, in addition, that the upswelling produced by this cause alone is sufficient to account for the elevation of the greatest mountain chains in the world."

Mr. Woodward leads the world to understand from these sentences that rocks, formed at the bottom of the sea, become dry land by the uplifting of the ocean-bed, caused by the two actions of contraction and pressure of the earth's crust in process of cooling. The theory seems to have been accepted by the Geological Association; the cloud is, however, clearing off in the horizon. At present, the words of Goethe are applicable to the situation ("Life of A. Von Humboldt"):—

> "What you don't grasp is wholly lost to you !
> What you don't reckon, think you, can't be true ;
> What you don't weigh, it has no weight, alas !
> What you don't coin, you're sure it will not pass !"

We will now briefly look at the merits of our quotations.

No. 1.—How is Mr. H. Woodward justified? There is no proof that the nucleus of this earth was ever hot. Till that proof is given, no one is justified in saying that it ever cooled by radiation, or contracted in consequence of that cooling.

No. 2.—A heterogeneous earth is certainly presented to us in its stratified sediments, but the contraction is supposed to have taken place before their formation. Mr. H. Woodward knows little of the conductivity or homogeneity of the rocks on which these sediments rest. No doubt, cooling goes on rapidly through water, but in the deepest part of the ocean found by the "Challenger," over five miles, the temperature of 33·9° Fahr. gives but little evidence of any radiating heat.

No. 3.—As far as natural laws go, the great continental areas were formed by river and ocean deposits on an undulating water bed. These laws require no unequal contraction; but as the agents of the law are varied in their forces, and act on varied material, it follows that these actions are the first stage of mountain formation. They are going on now on the ocean bottom.

No. 4.—If the exceptional 40,000 feet of sediment have yielded to horizontal pressure, we must examine the cause of this pressure, as suggested by Mr. Joseph le Conte. As far as natural laws are concerned, the effect of aqueo-igneous fusion in a mass must have had exactly a contrary effect.

No. 5.—The accumulation of sediments does not necessarily produce heat; gravel, sand, calcareous collections, give little or none; vegetable collections give much; animal collections give less. We find all these collections on mountain-sides. When heat does take place in collections of matter, the heat is near the centre, but the bottom is cool. Why, then, should an imaginary heat invade the sediment, and how are mountains made when the sediments are not 40,000 feet deep, with no heat in them? As no two borings or excavations to the same depth, from the same level in different strata, give the same temperature, Mr. Woodward had no right to assume an increase of one degree for every 58 feet in depth. This may apply to many others.

No. 6.—Alkali and water produce heat anywhere; if in sufficient quantity in sediments, they may produce hot springs or volcanoes.

No. 7.—The softening of sedimental strata, whether by water or fire, necessarily determines lines of yielding; if that yielding took place in the middle or at the bottom of 20,000 feet of earth, a subsidence would seem necessary under the ordinary law of gravitation. Putting 7, 5, and 4 together, the suggestion of Joseph le Conte seems absurd.

No. 8.—We have examined many mountain ranges of many structures in Asia and Europe. We have found thick layers of sediments; they are not always crumpled, fissured, and faulted. These conditions depend entirely on the character of the foundation, as well as on the action of subterranean waters percolating through strata, or running in sheets or streams under certain areas. Slaty cleavage can only be caused by the manner of deposit; no power of pressure can produce it.

No. 9 is a very ingenious supposition.

No. 10.—Slaty cleavage proves no upswelling, but it is evidence of a relative force acting on correlative matter. When mud is left to dry in the pools, the mud left by a current will exfoliate, because its fibre or grain was deposited by a moving force. The mud left by still water cleaves or cracks, because its fibre or grain sank and formed vertically. The law in both cases is gravitation. The law holds good on all material deposited by water. When these deposits dry they contract; there is no law of nature for the upswelling of these sediments. The law was first published in "Science Gossip" (Hardwicke), in May 1875. Mr. Kinahan, in the June number, thought it would "not be satisfactory" in all cases; he mentions several which could not, however, have existed under any other system, and then he says, "In some places the cleavage is perpendicular, or nearly so, in the pure argillaceous rocks, while as they become arenaceous it flattens, but in others the phenomena are exactly opposite." No other force, except that of water, could have deposited the different materials, with their grains in such opposite conditions. This will be better understood presently.

As Mr. Woodward embraced the theories of many others, whom he mentions in his address, his statement seems to show that in their opinion the mountains have been upheaved. Taken on their merits, the several points connected with those theories which we have now noticed appear to have no foundation. Mr. Woodward, however, believes in his own, and in the theories he has gathered together, "for," says he, "we are privileged in forming part of a race . . . which . . . has achieved the power to grasp the most hidden secrets of nature; to investigate and comprehend its laws, to decipher its monuments." In the Life of Humboldt we find a few words from Goethe applicable to the situation: "Able, clever, and bold thinkers dress up for themselves such a theory out of mere probabilities; they manage to gather round them followers and adherents, and then from sheer numbers gain a literary power; the theory gets pushed to an extreme, and is carried forward with a reckless impetuosity."

A word or two from one of our most trustworthy geologists will add force to this sentence as well as to our own remarks. In his "Manual of Geology," 1857, p. 265, Jukes says, The hypothesis of the earth having been once a molten globe "is one with which the geologist has little or nothing to do."

In the "Introductory Text Book," by Page, 1867, p. 25, speaking of the modifying agencies of this earth, we find, "Igneous agency as depending on some deep-seated source of heat, with which we are but little acquainted."

In the "Principles of Geology," vol. ii. p. 211, Sir Charles Lyell wrote: "The doctrine, therefore, of the primitive fluidity of the interior of the earth, and of the gradual solidification of its crust, consequent on the loss of internal heat by radiation into space, is one of many scientific hypotheses which has been adhered to after the props by which it was supported have given way one after another."

Having quoted Sir Charles to this effect, it is fair to show that he advocated an upheaval system. In vol. i., "Principles of Geology," p. 257, he wrote, The Alps have gained "4000 and even 10,000 feet in altitude since the commencement of the Eocene period. The Pyrenees have attained sometimes 11,000 feet since the deposition of the numulitic or Eocene division of the Tertiary period." . . . Then he tells us, "There has been no universal disruption of the earth's crust; . . . the non-occurrence of such a general convulsion is proved by the perfect horizontality now retained by some of the most ancient fossiliferous strata. . . . In Sweden and Russia the Silurian strata maintain the most perfect horizontality . . . so do the limestones and shales of like antiquity in . . . Canada and the United States, . . . (but) since their origin, not only have most of the mountain chains been uplifted, but some of the very rocks of which those mountains are composed have been formed." At p. 259, "The height to which ammonites, shells, and corals have been traced in the Alps, Andes, and Himalayas is sufficient to show that the materials of all these chains are elaborated under water, and some of them in seas of no slight depth." Precisely so. In the absence of dates for these organisms, or for the Eocene period, it is fair to assume or allow that the horizontal strata alluded to were formed while the mountain chains were still under water, and while some of their very rocks were being formed. This will be better understood when we see from our figures at what varied depths contemporary sedimentary matter is now being deposited.

In support of our assertion in No. 5, we find in the last-quoted authority, p. 205: "An increase of one degree for every 65 feet in Saxony, (but) in other mines of the same country it was necessary to descend thrice as deep for each degree"—this gives 195 feet. A well at Naples gave one degree for every 208 feet, and another a mile off one degree for every 83 feet. We might multiply these differences to a long list, but these will be sufficient to prove that the warmth of wells and mines depends on the constitution of the strata.

We close the evidence against upheaval by contraction or cooling, with a few words gleaned from a very true reader of nature, Mr. Evan Hopkins, in his "Geology and Magnetism," 2nd edition, 1851, p. 25: "We have only three primary divisions, viz., solid, fluid, and gaseous; we have no igneous liquids in a natural quiescent state." At p. 26, "Fire or the combustion of inflammable bodies, is nothing more than a violent chemical action, attending the combination of certain substances with oxygen." At p. 112, remarking on the present theory of volcanoes and earthquakes, as "the effects of an incandescent nucleus, *i.e.*, the violent action of molten matter in its attempt to burst and break through the thin shell of the earth, it is difficult to conceive how any rational being could for one moment encourage such notions." The thin skin here alluded to has been estimated by Mr. E. Hopkins at 800 to 1000 miles in thickness.

We may now say to the mountain-builders by contraction or cooling, with Goethe ("Life of Humboldt," vol. i. p. 193):—

> "Your sin is not a modern one, forsooth,
> To dream that theory may pass for truth."

We now come to facts given to us by the liberality of the British Government in fitting out the "Challenger" for a scientific voyage, under the command of the best officers available, assisted by a well-selected scientific staff.

These facts place before us a series of operations going on at the bottom of the ocean under the guidance of certain laws. These laws began with the beginning of the three elements—air, water, and earth. The works now going on have therefore continued from the beginning. The only difference is that the materials used in the works have changed.

At the present moment three-quarters of this globe are covered by water, all of which is liable to certain cosmical laws. We all see the tides flowing on and ebbing from our coasts. Most of us have heard of ocean currents, and some have read Maury, Rennell, and Jordan regarding them. Very little attention has, however, been paid to the cosmical labours of this never-resting force; we have not thought of what it does in its varied conditions. We may divide the current system into surface and bottom currents; these may be subdivided into main currents, eddies, backwaters, and whirls, caused by the conditions of the opposing coasts, or of the bed on which they rest.

The surface currents generally run from the equator to the poles; the bottom currents run from the poles to the equator. Mr. C. Wyville Thomson in "Good Words," 1874, p. 552, tells of a current between the parallels of 4° and 8° N. lat., "tolerably constant to the eastward," supposed to be caused by the rapid removal of surface water to the westward." Wherever there is water it is liable to be acted on by the atmosphere; currents and waves are formed, so that the ocean has two forces due to the winds, and two forces, currents and tides, due to cosmical laws, all of which vary as to strength in different regions, while varying constantly in the same. These forces are called aqueous agencies.

Mr. Page tells us in his "Text-Book": "The general tendency of aqueous agency, whether operating as rivers, tides, waves or ocean currents, is to wear down the higher portions of the earth's crust."

If, then, these forces have been working from the beginning, as we can show that they are working now, we establish the fact that the sea-bed must have been worn away during many millions of years; of its original depth we have no knowledge.

The accompanying table, taken from the "Challenger" reports of deep-sea soundings, as printed by the Admiralty, exhibits all the facts we require. These, with a few extracts taken from the text of the reports, will, we hope, enable us to make such deductions as to set before the world that, as the ocean-bed has for ever been worn away, its waters must have sunk, and its surface level must have been lowered :—

ABSTRACT OF SOUNDINGS FROM THE "CHALLENGER" REPORTS.

Section.	Nature of Bottom.	No. of Soundings.	Depth in Fathoms. Min. Max.
Gibraltar to Teneriffe	Mud	14	620 to 2250
	Mud sand	7	490 " 2125
	Red clay	10	2740 " 3024
	Coral sand shells	1	78 ...
	Coral	1	670 ...
	Sand	1	1340 ...
	Rock	2	179 " 2021
Teneriffe to Bermuda	Grey ooze	7	950 " 3875
	Coral mud	6	120 " 2450
	Coral shells	1	435 ...
	Coral	1	30 ...
	Red clay	3	2600 " 2850
	Sand	3	175 " 1370
	Rock	3	125 " 780
Bermuda to New York	Grey ooze	5	1700 " 2650
	Sand mud	3	124 " 1300
	Rock	1	51 ...
Halifax to Bermuda	Grey ooze	6	1250 " 2800
	Mud	2	1250 " 1575
	Grey clay	2	1075 " 1325
	Stones and gravel	1	83 ...
	Rock	1	1775 ...

Section.	Nature of Bottom.	No. of Soundings.	Depth in Fathoms. Min.	Max.
Bermuda, Azores, Madeira, and Cape Verd .	Grey ooze . .	12	1150 to	2850
	Globegirina ooze .	18	900 ,,	2400
	Mud . . .	2	1000 ,,	1070
	Volcanic sand mud .	2	465 ,,	1125
	Rock . . .	12	1675 ,,	750
Cape Verd, St. Paul's, and Fernando Noronha . . .	Grey ooze . .	3	2275 ,,	2500
	Globegirina ooze .	10	1750 ,,	2675
	Mud . . .	2	2475 ,,	2500
	Rock . . .	1	1010	...
Noronha to Bahia and Cape of Good Hope .	Globegirina ooze .	6	1900 ,,	2275
	Mud of varied colour	21	250 ,,	2650
	Shells . . .	1	1000	...
	Sand coral . .	2	32 ,,	120
	Rock . . .	3	820 ,,	2100
Cape of Good Hope to Melbourne . .	Globegirina ooze .	7	600 ,,	2150
	Diatom ooze . .	2	1260 ,,	1950
	Mud . . .	4	1300 ,,	1975
	Red clay manganese	1	2600	...
	Sand shells . .	2	98 ,,	150
	Gravel . . .	1	150	...
	Rock . . .	2	210 ,,	550
Sydney, New Zealand, Fiji, and Raine Island .	Grey ooze . .	13	150 ,,	2275
	Globegirina ooze .	4	400 ,,	1975
	Shells . . .	2	85 ,,	135
	Coral . . .	3	240 ,,	315
	Red clay rock. .	10	130*,,	2900
	Hard sand . .	3	120 ,,	290
	Rock . . .	4	130 ,,	630
Torres Straits, China Sea .	Grey ooze . .	3	1050 ,,	2550
	Mud . . .	3	580 ,,	800
	Red clay . .	4	2100 ,,	2800
	Rock . . .	1	825	...
Philippine Islands, Sulu and Celebes Seas to China . .	Mud . . .	5	84 ,,	700
	Grey ooze . .	3	2000 ,,	2325
	Globegirina ooze .	6	500 ,,	2000
	Red clay . .	12	2050 ,,	4575

NOTE.—Every change in the bottom denotes a correlative of material to the force which deposited it. The soundings from England to

* The shallowest red clay, most likely under the protection of some projection in the rock.

Gibraltar are not given. There are then 271 soundings, divided into mud, ooze of sorts, broken up shells, coral mud and coral, coral sand and shells, shells, volcanic sand and mud, red clay, grey clay, mud and sand, sand, stones and gravel, rock.

From these facts we make the following natural deductions in three parts :—

1st.—The rocks could not be bare unless there were forces to keep them so. Stones and gravel must have been broken and deposited by force. Sand could not be made or deposited without force. Mud and sand together give evidence of organic dust mixing with heavier matter under the influence of variable forces. Red clay has been separated from other matter by water forces, and left to sink by its own gravity. Grey clay is due to similar action. Volcanic sand and mud exhibit a grinding up and deposit by force. Shells are brought together by surface, middle, and bottom forces. Coral sand and shells tell of forces acting on varied material. Coral mud is produced by decomposition assisted by force. Coral entire tells of recent formation or recent removal. Globegirina and other ooze tell of decomposition and separation by force. Mud tells of decomposed matter of all sorts, deposited in still water.

2d.—As all these actions are done under cosmical laws, it follows that the same laws, acting from the beginning on the varied material submitted to their sway, placed these materials in the horizontal positions noticed by Sir Charles Lyell, and exhibited to us in our sea-shore cliffs, in the mountain precipices, all round the world—in our mines, quarries, wells, and tunnels, as well as in all the gorges and canons excavated by river forces.

3d.—Under the action of forces working on the water-bed, it will be obvious that this bed must have been worn away. When this happened, and when there was no material at hand to fill up the place, it follows that the water sunk into it under the law of gravitation. As there was a time when this was doing all round the globe, this sinking of the bottom must have caused the sinking of the surface.

These deductions will be more clearly shown in the sequel.

To enable us to record as large an area of the present sea-bed as possible, we now quote from the "Geographical Magazine" for October 1875 the recent soundings of the

"Valorous" in Davis Straits, and in an unknown portion of the North Atlantic. In latitude 64° 5′ N., longitude 56° 47′ W., at a depth of 410 fathoms, molluscs were found. Coming down the Straits, 1170 fathoms gave foraminifera; 1750 fathoms gave the remains of globegirina and other organisms. In the Atlantic, between 58° 14′ N., 46° 29′ W., and 35° 10′ N., 25° 58′ W., at depths varying from 690 to 1860 fathoms, the rod or the dredge brought up globegirina ooze, stones, exquisite silicious sponges, brachiopods, foraminifera, black volcanic stones, echinoderms, annelids, and mud in seven soundings or dredgings. The 690 fathoms here mentioned tell of a ridge "about 400 miles S.E. of Cape Farewell." Stones brought up were sharp and angular—"not water-worn as would have been the case if they had been conveyed any considerable distance by a current. We presume that, whether carried there by ice or broken off the sea-bed, they tell of a force of some kind in the ocean.

Returning to the labours of the "Challenger," Captain Nares, remarking on the section between Sandy Hook and Bermuda, writes, paragraph 6: "The dredge indicated that various deposits were going on at different times. This would naturally be caused by an occasional change in the direction of the bottom currents," or, we may say, to varied materials in the currents. At paragraph 12 an example is given of a surface current "rushing past us like a mill-race." In his report of 16th March 1873, paragraph 7: "The rocky nature of the bottom . . . would indicate a considerable movement of the lower stratum of water."

We have, then, direct evidence of bottom currents from the pen of Captain Nares, and proofs of them in the varied natures of the sea-beds as shown by the "Valorous" and the "Challenger." We continue the history of the sea-bottom from letters of Mr. C. Wyville Thomson from the "Challenger" to "Good Words." These give ocular evidence of the materials brought up, and the very condition of the ocean forces by which they were deposited.

A sediment of red clay, "in the finest possible state of subdivision," was found over vast areas in the Atlantic. We do not touch on the interesting subject of its composition; but, says Wyville Thomson, p. 46: "When the globegirina ooze and the red clay passed into one another, it seemed as if on one side of an ideal line the red clay gradually contained more and more of the material of the calcareous ooze, while on the other the ooze was mixed with an increasing proportion of the red clay."

He then tells us, that the "mid Atlantic . . . swarms with pelagic mollusca, . . . that the shells of these are constantly mixed with the globegirina ooze; . . . but not a trace of them is ever brought up . . . in the red clay area." Allowing that Mr. Wyville Thomson is right in his theory as to the cause of these deposits, it is obvious that these surface pelagic shells had a vast depth to travel through before they reached a resting-place; as all dead organisms resolve into their respective elements in course of time, it follows that these shells often become decomposed in transit. All the shells that fall entire, or broken up, on to the ooze formations, were carried there by the currents which graduated the mixtures of ooze and red clay. As the clay, however fine it may be, is heavier in proportion than a minute calcareous atom, and as a large calcareous atom is more liable to the water force, it follows that these forces place the calcareous atoms on areas different from the clay areas. Though a current must exist at the level where these gradations of material are found, it does not follow that any current exists on the lower level where this finely triturated clay is chiefly deposited, so that Wyville Thomson is right when he says: "The idea of a current sufficiently strong to sweep them away is negatived by the extreme fineness of the formation which is taking place." We have noted in our table an instance of red clay, bracketed with rock, at a depth of only 130 fathoms, while it is generally found at great depths. The presence of red clay in this position indicates a current over an uneven bed; the lightest materials take advantage of all projections that offer the chance of a resting-place. In his address to the Geological Society, as published in the "Mail" of 21st February 1876, Mr Evans remarked that the "Challenger" had found "no less than five absolutely distinct kinds of sea-bottom." Considering the variety of materials entrusted to the care of the deep waters, it is almost wonderful that greater changes are not found; but we must remember that triturated remains of primeval rocks mix with the remains of rocks of all ages, and with all the dust from the uncounted organisms of land and water, that water has the power to assort all heterogeneous mixtures into comparatively homogeneous masses, and to deposit in their respective places all the atoms under its control.

Our geological schools have avoided water subjects for many years with a pertinacity that savours much of scholastic hydrophobia: we are rejoiced to find in what follows certain symptoms of a speedy cure.

Mr. Wyville Thomson, writing in the above-quoted letter on the red clay formations, supposing them to be derived from organic matter, says: "It is impossible to avoid associating such a formation with the fine, smooth homogeneous clays and schists."

Mr. Evans, in the address above alluded to, said, "We have this important discovery laid before us, that there are existing causes at work which, at a great distance from land, and without the aid of any transported sediment arising from denudation, suffice for the tranquil deposit of beds of red clay on the bottom of a deep sea, these beds shading off under different circumstances into deposits closely resembling our lower and upper chalk, and upper green-sand formations. It will be for geologists to determine whether not only these rocks, but others of older date, but especially clays and slates, may not have their origin assigned to the action of similar causes." On this we remark that when land denudations are handed over to ocean currents, there is no knowing how far they may go.

Professor Huxley, lecturing on the work of the "Challenger," as reported by the "Hour," 1st February 1875, told his audience that "Ehrenberg had been for fifteen or sixteen years advocating the theory, that chalk was the same as modern deposits." It is of no consequence to our subject as to what the deposits of to-day are composed of; their formation proves the fact of their constituents having been submitted to the forces of water or wind; the coral sands of Bermuda could not envelope large areas of cultivated lands, unless they were correlative to the forces acting on them—that is, all the atoms obeyed the winds blowing them from the reefs to lodge them there. The sand-dunes of Holland owe their formations to the relative forces of the winds that blew them there; even mud-banks, sand-beaches, pebble and shingle coasts, are all correlatives to the forces that brought and left them there. We have analogies to these actions constantly before our eyes. The dust that floats and dances in the sunbeam glancing through our rooms is, in its respective actions, correlative to the force that acts upon it. The fleecy vapours that stream away into the blue atmosphere from the heavier clouds are obedient to a force acting on them. The snow-wreaths that are heaped up in vast volumes by the winds are analogous to the vast drifts of unstratified sands, gravels, and muds heaped up by water forces when laden with matter. Thus we reach the facts that all atoms, deposited by wind or by water, must have been brought there by forces relative to the atoms deposited; the heavier the atom, the greater the force; while bare rocks tell of the greatest forces that suffer no atoms to rest upon them. Passing downwards through the groups, systems, and epochs which geological science has classified for our guidance, we find all of them full of evidence of these facts; we find bare rocks, or rather rocks that once were bare; boulders with their unstratified tails below them, pebbles, gravels, coarse and fine sands, clays, calcareous and argillaceous deposits, all evidences of varied materials subjected to varied forces at varied times—all proving that forces similar to those now existing must have existed in all time.

By slow but certain steps we descend through recent formations into strata full of relics of organic structures, the history of whose existence in life or growth is utterly lost; passing on we come to rocks formed from organisms that can only be detected by the microscope. Below these we reach silicious rocks in which no organisms have been detected. Similar rocks form our ocean beds, we find them below and on the water level; our rivers find them and erode them; they are found in our mountain tunnels and on our highest mountain tops. From the highest to the lowest locality of this earth we find these silicious rocks of varied character in stratified and unstratified conditions.

How did these rocks get there? and from whence did their materials come?

Before organic dusts covered the water-bed, the cosmical currents, the wind currents, tides, waves, eddies, and whirls, all applied their unbridled forces to wear away their own beds, as they wear them away now when they find the opportunity, to move along the biting sands and gnawing gravels, over the ever-yielding rocks, breaking all that could be broken to the smallest size, liquefying all that could be liquefied, and moving on solutions, suspensions, rolling atoms, and movable masses, until the gravitation of each individual overcame the relative force opposed to it, and sunk to rest all in their respective places.

The materials for the sedimentary silicious rocks came, then, from the sea-bed, and were brought to their resting-places by the water forces, as surely as the mud-banks of to-day are lodged by the same forces from the soft materials submitted to their care.

It seems, then, that these actions are due to certain cosmical laws which must be coeval with the elements; that under their labours the bed on which the waters first rested must have been made deeper, and the surface-level must have sunk. No one can say where that level once was, and no one can tell the depth of the primeval waters; our highest mountains tell of its presence at 28,000 feet above its present site, our geologists tell of vast denudations from higher regions, and the strata of our highlands tell of shallow places. There is nothing against this theory in the laws of nature, but we may here say with the Psalmist: "He founded it upon the seas, and prepared it on the floods, and His footsteps are not known."

Are we now in a position to solve the difficulty of geologists, as expressed by Mr. Jukes? His "shell of water, ten or twenty thousand feet deep, enveloping the whole globe," now envelopes some three-quarters of it to an extreme depth, as far as yet discovered, of about 27,450 feet. We cannot say there has been any loss of water, but there has been a certain gain of dry land.

The great cosmical system, which we have endeavoured thus briefly to describe, seems to have nearly reached its equilibrium. We hear of the sea receding from one place and encroaching on another. The direction of ocean-bottom currents must change, as rivers change their channels; but whenever they do so, organic matter now fills up the depths, and organic matter is met for a time wherever the currents move to.

May we now thank the Government of Great Britain for the assistance given by the "Challenger" and her officers, and scientific gentlemen, as well as to the "Valorous" and her officers, for the facts and discoveries laid before the world. If the problem of the sinking of the sea-level is solved, the solution is due to them. We lay down no dogma, we try to adhere to the cosmical law, and to mark the action of its agents. The agency we have followed is and has been competent to the work we have assigned to it. The agency employed by our geological school to produce the same effect seems wanting in its foundation. When this foundation is secured we will gladly reconsider the case, till then we adhere to the sinking of the water-bed level as due to the erosion of the water-bed, and leave the case in confidence before the jury of our country.

CHAPTER X.

THE PHYSICAL EDUCATION OF DUST—EARTHQUAKES.

THE "Quarterly Review" of 1st January 1869 tells us, the most popular notion regarding these phenomena "*is the hypothesis of contraction of the mass of this globe by radiation of heat into space.*" If we examine this sentence by geological reasoning, confining ourselves to those things and actions which are visible and tangible, we find two causes of objection to it. We ask, Whence is the heat to radiate into space? and where is the mass capable of contraction? There are certain laws which rule atoms and worlds; we have only to understand these laws and their results to enable us to comprehend every phenomenon upon earth; man has not been able to do this, but has sought interpretations from his own imagination, till he has been led into innumerable difficulties. Man has been trying to find an imaginary self-existing fire in the centre of this globe for many years without success; he does not like to give it up, it is a very convenient and irresponsible agent; at this present moment the Underground Committee of the British Association are amongst other things experimentalising for it on the Wealds of Kent. "The Mail," 24th December 1875, publishes a letter from Mr. Willett, alluding to "strange and inexplicable phenomena" incident to these experiments. The results of the labour can be anticipated, a higher temperature will be found with depth, but not so great as in a coal-mine. Heat must be found wherever there is pressure; good reasons have been placed before the world that this heat originates in local causes, we will accept them till they are proved erroneous, or till a self-existing fire is discovered, and in the meantime we assert that there is no proof of *radiation of heat into space* from the interior of this earth.

Man has long imagined that the substance of this earth, beneath the sedimentary strata resting on it, is one uniform, all-pervading, all-surrounding envelope, commonly called "*The Crust.*" Its interior face is supposed to rest on the central fire, and to be always in a molten condition at some 25 or 1000 miles beneath our feet; as this heat decreases by distance from the fire, the outer face naturally contracts on cooling. This contraction has been supposed to cause earthquakes, to expel the molten matter up to the surface, and to raise up mountains on it.

A popular notion is a very unsafe mooring, and not one in ten thousand of those to whom the "Quarterly" alludes could tell us how he formed that notion. Nevertheless, it is popular; and its popularity is due to the fact, that there never was a time in English history when men followed the lead so blindfold as they now do. A few eminent pens have written out the theory, they have described in touching language how various surface phenomena have been caused by the contraction of the crust, scientific pens have shown that this crust must be nearer to the surface in some places than in others under the ordinary process of denudation; the "Quarterly" throws his weighty pen into the scale, and so we have a popular opinion, founding a surface phenomenon, which we see and feel on a crust, of which there is no measurement. If there was any doubt or uncertainty in the opinion we might excuse it, but what can we say to the pen that writes, "*This earth was once an igneous globe.*"—"*There came to be formed a solid shell*"—then a "*cracking*" and "*crumbling*" of the earth into its present irregular surface, for in those days "*there were earthquakes on the grandest scale*"? This sounds very exciting, but it is all imagination.

There are certain fixed laws which tyrannise over this world, its atoms could not be as they are without these laws, and the laws could not exist without the atoms. These laws are beyond our control; men are as liable to them as an atom of dust, or as the mass of the Andes. In the "Times," 4th October 1872, it is shown that Quito has sunk 246 feet in 125 years, Pichincha 218 feet in the same period, and Antisina 165 feet in 64 years. If we take away the support of an atom, it falls till it finds another; if a man loses his footing he falls: there is a perpetual wearing away of subterranean, as well as of surface matter, so that supports are perpetually failing, and everything is liable to the laws of gravitation, even to the highest mountains of the earth.

There are natural forces always at work, which bring matter under the law. The wind lifts up dust from the earth, and some of it falls again. The rain falls to the ground, and percolating through it till it finds an impermeable stratum, gravitates along its surface till a level is found. Wherever we find water in a moving condition, we see that matter moves along with it. Water and air move all things that submit to their influence as long as they are correlative to the force. Wherever subterranean water runs it must act as it acts on the surface, eroding and moving on something in every inch of its progress. Under the action of these never-wearying forces, certain areas or portions of this earth's surface must occasionally be left without their natural supports; so that these areas, either in part or whole, become liable to the law of gravitation. With pressure from above, no support, or a soft one below, and a material deprived of its adhesive power, there is, there always has been, and there always will be, a tendency for earthy matter to work downwards.

This tendency may be illustrated by the following examples. The "Athenæum," 9th October 1869, mentioned an earthquake at Murwut, East India, where the "underground moisture is commonly found two feet below the surface;" it rose after the earthquake to "about six inches below the surface, not in one spot only, but throughout the sandy tract of the district." In this case the sand being dry and untenacious, without sufficient support for its weight, sunk bodily into the water-bed; so that the moisture rose to near the surface. This action is very common in sandy regions, but is seldom noticed, even in our footprints; if the sand on which we tread is dry on the surface, the impressions of our feet sink into it, and these impressions are sometimes damp, sometimes full of water, according to the depth of water down below. In the "Times," 6th July 1871, an earthquake is recorded at Bathung, in China, over an area of some 400 miles, when "black fetid water spouted out in a furious manner." The nature of the soil is not mentioned, but it fell into and displaced the water below, so that, having no other channel of escape, it was forcibly ejected through the crevices made by the fall.

In 1783–86 constant shocks of earthquake took place in Calabria, with upbursts of "water and sand," "not fewer than 215 lakes and morasses were occasioned by displacement of the ground." The "Quarterly" also says of other regions: "Violent vibrations, down-sliding of hills, stoppage of rivers, formations of lakes, in-rushing of sea-waves have taken place."

All these cases, and many more might be added, illustrate the subsidence of the upper strata into the water-bed; if the phenomena had been caused by the contraction of the cold crust, as so many imagine, the water must have gone down through the cracks of that contraction; if, on the contrary, they had been caused by the subsidence and shrinkage of the earth's exterior, as asserted by Mr. R. Mallet, "Spectator," 5th October 1872, into the "retreating nucleus," then again there would necessarily be fissures below the water run, and as there would be no force to eject it, all the water on the site must of necessity have gone down; so that there is no escape from the conclusion that earthquakes may originate in the mass of matter overlying the water-bed, and they have no necessary connection with volcanoes. Earthquakes that happen without water ejection are by no means dependent on any igneous action, or on any contraction of the earth-rocks below, as the following example will show:—On the 17th March 1871, an earthquake was reported in the lake districts. The "Times," of April 3, admitted a letter saying, that this earthquake was attended with "a concentrated hissing sound." On the 25th March the "Kendal Mercury" printed a letter which thus explains the phenomenon:—"We had a dry summer last year, our springs sank unusually low, our winter snow and late rains have now percolated into the strata above the subterranean water-levels, and the extra weight of the water has forced these strata into the beds or cavities below,"—an action corresponding to what we have said, and one that must of necessity force out the air or gases, which had collected in the empty water runs, the hissing sound depending on the character of the orifice through which it was expressed. It will be understood that this expulsion of air is precisely similar to those actions, which eject gases from the surface in many parts of the world; though the subsidence which supplies the force may be either sudden or slow. There are many instances where other matter than water or air is acted on by landslips, subsidences, or earthquakes. In the Under Cliff, Isle of Wight, and near Folkestone, great masses of cliff have slipped bodily into the black Gault below, and this mud, full of fossil-remains, has been forced up through the crevices, and in great masses, along the face of the broken cliff, where it joins the sands of the sea-shore. At a considerable distance from that line, at Folkestone, a ridge was forced up on the sands near low-water mark, equal in length, and parallel to the landslip. Tides and waves had nearly obliterated this ridge when we examined it, but the sheet of black Gault which had been forced down the water runs was still visible in places, of varied thickness; explaining how sheets of one material become interstratified with other materials, for which science has as yet found no explanation. The elevation of the line of sea-shore in Chili, in 1822, and the upheaval of the Ullah Bund, in India, in 1819, are both actions of a similar nature, and no similar elevation of the surface earth can be attributed to any other cause than a corresponding subsidence; so that in all these and in many more instances we confirm the opinion of Professor Haughton, who said of other cases, "Their characters are totally different from those of volcanic phenomena," "showing the two classes of phenomena have a different seat."

There is, then, trustworthy evidence to show that earthquakes do not necessarily depend on *volcanoes*, or the *contraction* of the mass of this globe by radiation of heat into space, or by the *shrinkage* of the earth's exterior into the retreating nucleus; but we must briefly examine how far volcanoes may be dependent on earthquakes.

Science has not made up its mind as to the origin of these igneous phenomena. In a late address to the Geological Society, Mr. Evans was reported as believing in the inherent internal fire, as the cause of all igneous phenomena. The "Spectator," of 5th October 1872, discards one fashionable theory thus, "It is now generally admitted that if the earth really has a molten nucleus, the solid crust must nevertheless be far too thick to be in any way disturbed by changes affecting the liquid matter beneath." Another theory of local molten basins he disposes of by saying that "such lakes could not maintain their heat for ages." It is now some years since we discarded these theories in "The Interior of the Earth." The "Spectator," however, says, "A theory has just been put forward by the eminent seismologist, Mallet, which promises not merely to take place of all others, but to gain a degree of acceptance, which has not been accorded to any theory previously enunciated." While fully allowing the position assigned to Mr. R. Mallet, and giving him full credit for accuracy of observation, experiment, and calculation, we must take the liberty of examining this theory so far as it is set before us. It is shown "that the hotter internal portion must contract faster than the relatively cool crust," and so "the shrinking of the crust is competent to occasion all the known phenomena of volcanic action;" "as the solid crust closes in upon the shrinking nucleus," the crushing induces heat, and so "the access of water to such points determines volcanic eruption." If by the solid crust of the earth is meant a substance similar to any of the rocks we fall in with on the surface, then there is no evidence to show that the crust is continuous, or solid, while nothing but a continuous solid rock could meet the theory. If, again, this is the substance alluded to, we have evidence to show that the void hard rock is cooler at a depth of some 5000 feet than in coal-mines at 2000 feet, so where does the supposed contraction begin? We rather think that Mr. Mallet has done more to destroy the great myth of internal self-existing fire, than any one of the Plutonic school has done to keep it alive.

With these brief remarks we pass on to our little history. We do not demand credence to it; the facts are before us, always in action. We only ask those who take an interest in the subject to think for themselves, and, sooner or later, they will recognise the picture before them. The inhabitants of volcanic regions, on hearing grumblings and feeling vibrations, say, "The mountain is in labour." We all see what vast collections of matter are brought together by the water drifts. We know that, season after season, materials of one description are brought to the same spot, and we see on our cliffs, and in our mine shafts, the thickness of these strata. We know that out of these strata, and these deposits, man obtains combustible and inflammable materials, yet has he been unwilling to allow that Nature's laboratory is equal to his own. Some have rejected the natural chemical theory of Sir Humphry Davy and others, that volcanic action depends on local chemical causes. It has been boldly and falsely asserted that the cause was not equal to the effect, and that the chemical energies of our earth's materials were almost wholly exhausted before the surface was consolidated. Nevertheless, the hot spring flows, and the mountain labours. There may be local exhaustion, but the energies of the earth are never lost, though they may change from the inanimate to the animate, and back again. Let those who suffer from these active energies talk of Nature's exhaustion if they please, but those who sit in their rooms, and theorise on the subject, may as well hold their peace. Who will venture to limit the quantity of any material, igneous or not, which may have been collected into one region by the natural forces working at it for unknown millions of years? The earth is full of alkalis, as well as of gaseous materials. Spontaneous combustion takes place in the little cargoes of our ships. Can we refuse a similar faculty to the great collections of the earth? The material is all the same; nothing is hid in the strata of this earth that was not once a partner in its surface produce, and nothing but earth's produce takes fire in a ship's hold. We can neither limit the collection of matter, or measure the energy of a collection. The mountain in eruption discloses that, and the extinct volcanoes tell of local exhaustion. If volcanoes were caused by the issue of heat from the imaginary furnace of the earth, if the shrinking of the inner crust produced mechanical causes of heat, and these were converted into flames or steam by contact with water, there would be no cause why an eruption, once commenced, should ever cease. We know the force with which heat flies to a cooler atmosphere; a channel once opened to that fire region could never close again, eruptions could never cease, and lava would flow while there was granite or basalt to melt. Volcanic action is, however, spasmodic, and craters do close up; and so we at once come back to the earthquake cause of the volcano. We have got our heating substances inside the earth, we have got water percolating through the earth, we have vacant areas beneath the surface. Along these water-courses, and into these areas, the earth subsides or falls. There is no choice of locality for these actions. The sandy plain, and the highest mountains in the world, are alike liable to the law, and thus earthquakes are felt in volcanic regions previous to eruptions.* It

* These actions are confirmed by the "Times," of 1st November 1872: "Advices from the Sandwich Islands report the volcanoes of Mauna Loa Kilauea in a state of active eruption, and it is stated that the shores of the island are sinking."

is only in these regions that this effect takes place, and in these Nature has deposited the materials which produce heat. These materials are as liable to the eroding action of water, as any other materials; they are also as liable to the laws of gravitation. The grumblings and vibrations felt on the surface must be caused by this law, in the act of placing heating matter under the influence of water. At this point we meet other geologists; the only difference between us is, that our igneous material falls into the water; while their water falls into the fire. We believe that we have already opposed insurmountable obstacles to this action; but we will now say that, if the heat below our feet is a gradual progressing one, till at 25 miles, or at 1000, it could melt the hardest rocks, and if the contact of water with these rocks is a necessary prelude to an earthquake or a volcano, then neither of these phenomena could ever have been seen or felt upon earth. If the water that percolates through the strata could by any possibility reach the imaginary molten rocks, the action of the volcano would be regular, and could never cease; its action is, however, spasmodic, at long intervals, indicating fresh energies; these must be supplied by new matter as shown above: when this is burnt out the spasm ceases, and so a volcano sleeps and wakes, till no more heating materials are available.

To carry out our system of making each subject as complete as possible, we here notice the only objections that more than three years have raised to this doctrine. In February 1874 the "Geological Magazine" published the following letter :—

"ORIGIN OF EARTHQUAKES.

"I cannot think Mr. Malet has satisfactorily accounted for earthquakes, referring them to the action of water percolating underground, wearing away the rocks, and by so doing causing subterranean landslips. Surely if it is to this that earthquakes owe their origin, they would be found occurring in every country, but far more frequently in those in which is the greatest rainfall. Great Britain and Ireland are probably the most rainy countries in Europe, and accordingly ought to be those most severely shaken by earthquakes; nevertheless, these are countries nearly entirely exempt from such shocks. No doubt many earthquakes do occur in England every year, but of so slight a character as to be perceptible only by special instruments for detecting them, and Mr. Malet is evidently referring to those of a more severe character.

"On the other hand, when we appeal to that observation of facts on which Mr. Malet lays rightly so much stress, we find a close connection between the distribution of volcanic areas and the frequency of earthquakes ; both volcanoes and earthquakes have, in the main, developed themselves in the same directions, and the latter increase in frequency on approaching the focus of volcanic activity.*

"Again, we hear of earthquakes ceasing when a new volcanic vent has been formed in the district, or an old one re-opened.

* When volcanoes cease for a time, earthquakes are rare in that area. When they begin again earthquakes are again frequent, because there are two causes at work undermining the strata, so that after a time the quakes multiply.

This is apparently another indication of the community of origin of volcanoes and earthquakes, the former acting as a safety-valve to the latter ; but by Mr. Malet's theory, I can see no explanation of it.

"Again, we know that eruptions are attended and preceded by earthquakes, though not of the first magnitude, but instead of considering the eruption the effect of the earthquake, it seems to me more reasonable to assign them both to a common cause, namely, the expansion of subterranean matter causing rendings in the rocks from an over state of tension, and when, as in this instance, occurring at a comparatively slight depth, the melted matter forcing a way to the surface will flow over it as an eruption. The greatest earthquakes frequently take place far from volcanic areas ; but we may, I think, with some confidence refer them to the same cause producing the minor shocks; only that taking place at too great a depth for the melted matter overcoming the resistance of the rocks above to force a passage to the surface ; consequently no eruption follows. A. COLVIN, F.G.S.

"NEW UNIVERSITY CLUB, ST. JAMES'S STREET, S.W.,
December 22nd, 1873."

We have said a good deal on this subject in our Subtraction and Division chapter, but as others may have imbibed Mr. Colvin's ideas, a repetition under this heading may be useful. Taking the letter as it comes; it is not the quantity of rain that makes earthquakes, subsidences, and landslips, but the foundation on which the falling strata rest,—the condition of the strata through which the rainfall percolates, as well as the strata between which the collected water runs in its subterranean course. Some earths erode easier than others ;

some strata subside when wet, others when dry. Deposits resting on slopes subside more readily than those on flat foundations. Some, when undermined, remain as they are by natural cohesion. There are subsidences which take place slowly, unobserved; there are others which take place suddenly, as earthquakes and landslips, names given to the importance of the movement, but all belonging to the earthquake family.

Earthquakes are most frequent in active volcanic regions. Igneous earth is as liable to water erosion as any other earth. It has two inducements to break up, —heat to act chemically, water to act mechanically. Wherever there are deposits of igneous earth, they produce heat; this heat determines the quantity and quality of the volcanic energy. Mr. Colvin places his cart before the horse in his second paragraph.

Of course the earthquake ceases when a new vent is opened, or an old one reopened; all the igneous material available has been used for these results. The vents give relief to the buried gases, the sunlight, and to the expanded water. As Mr. Colvin remarks, "the open vents are safety-valves to the action of the earthquake, and its consequence the volcano."

In his last paragraph Mr. Colvin thinks that earthquakes are assignable to the "expansion of subterranean matter." There is obvious truth in this; the whole system depends on loosening, freeing, and expanding the gases, the igneous matter, and the rocks. Unless these events happened to take place, there would be no subterranean matter to expand. It is the absence of expanding gas, water, and earth that prevents any symptoms of volcanic energy, when great earthquakes take place, "far from volcanic areas."

Minor earthquakes take place on the banks of the Arno, great ones on the Mississippi. We have mentioned their occurrence at Murwut, in China, and in the Valley of the Indus. They may be great or small, but if there is no igneous deposit, there is no volcanic energy.

We hope we have sufficiently explained Mr. Colvin's objections, and made it clear that, though volcanoes owe their origin to the expansion of igneous earth, under the action of a subsidence or an earthquake, these and all landslips may, and do, take place, far from volcanic action, under the natural laws of subterranean movements.

We have thus briefly and imperfectly given an interpretation of phenomena which happen on the surface of this earth. In endeavouring to fathom their causes, it seems that people have been led away from Nature's laws, and have tried to explain the subject by bringing in an agent, whose existence is not proved. The new theory, noticed by the "Spectator," is only one more proof of the unsatisfactory explanations dependent on an imaginary self-existent heat. Till this heat is proved to exist, every theory based upon it must be rejected, and the greater necessity is there of determined rejection, when we find that these phenomena can be interpreted by natural laws.

While the sun shines, and rain falls, while air, earth, and water produce, while these productions pass on to burial, so long will combustible matter be passed on by water, attraction, pressure, and gravitation to its peculiar burying-grounds ; where, sooner or later, it will again be made use of to produce phenomena which have been so little understood.

We walk along the ocean shore, or by the river bank, we see the atoms moved along, we watch the landslips, and the avalanche, we walk on the dry sand and see the water rise in our footprint, and we see in these familiar scenes details of those vast actions which are for ever at work somewhere. We have only to expand our minds to keep pace with these actions which we call phenomena. All the agents we use are visible, all the materials are tangible; a geologist has no business with the intangible or the invisible. For many years man has been seeking for a self-existent fire beneath our feet without success ; he has found some heat in the earth, where it must necessarily be under the ordinary laws of pressure, with certain conditions of deposits. Man has not gone beyond deposits, and has no right to assume a state of things in a locality of which he is ignorant. This is fairly illustrated by late publications. "The Mail," 8th January 1877, in noticing Lectures on Physical Science by Professor P. G. Tait, tells us "the Nebular hypothesis of Laplace must be accepted as the explanation of the source of the sun's energy." We learn from an article in the "Quarterly Review" for July 1876, that, under this theory, the sun, on condensing, stored up heat to last at the present rate of consumption for "20,250,000 years;" also that this earth "must have formed part of the fiery mass of the sun." The earth must, therefore, have inherited its relative portion of heat. This brings on a curious result, which science has not considered advisable to mention. If the sun, with a diameter of 850,000 miles, obtained a store of heat to last for the above period, then this earth, 8000 miles in diameter, inherited a store of heat to last for 190,588 years. We leave it to those who advocate the theory to find out if this store of heat would satisfy their supposed radiation of heat from the earth, its volcanoes, hot springs, and other igneous phenomena for their 10, 15, 50, 100, or 300 millions of years, and for our eternity. So we come to our simple conclusion. The earthquake takes place when the area becomes liable to the law of gravitation, and falls, as a snow avalanche falls over the face of a precipice, because it cannot help it.

CHAPTER XI.

BASALT.

"The stony rocks are not primeval, but the daughters of time."
—LINNÆUS.

"A man without a mental picture is unfit to be a philosopher."
—TYNDALL.

WE now intrude our ubiquity into the hearts of some of our hard relations. Simple, natural, and all formed under certain infallible laws, at varied times, these rocks have been thrown into such chaotic confusion by the mental pictures of philosophers, that it is impossible to find truth in them.

We were once rebuked by a nameless critic for venturing to place before the world certain geological facts without quoting authorities. As a rule, our authority is the law of creation; as long as we adhere to that we require no other. If we venture on imagination, and reject the law, our ideal is as good as that of others, who also reject the law.

The critic was, however, right, according to the satirical remarks of Goethe: no one would believe anything new of geology that did not tally with his own theory.

If the critic was right, we were wrong; in endeavouring to avoid this error now, we quote mental pictures from many philosophers. There cannot be two of them true to the original, possibly not one; but we ask those who read the laws of nature, and those who have followed our clue so far, to think the pictures over, and to select that which reveals nature in her naked truth and wondrous beauty. All that we dusts desire is the most searching inquiry. We endeavour to place the whole truth upon our pages; we may fail in its entirety, but we open a door for others to enter, to satisfy our omission; we begin our rock relations with basalt.

We passed many years of our life amongst the basaltic regions of India; broken-sided, blocky-topped highlands, with great tors sticking up in one place, and tall spire-like columns in another. As we roused the spotted leopard from the cactus thickets on the hill-side, as we followed the wild-boar over the hill-tops, strewed with basaltic blocks from the size of a hat to the size of a house, we could not avoid seeing that the fragments round us were the remains of higher places; vast mounds, heaped up in utter confusion, told of broken tors, long lines of shattered rocks told where lofty spires had fallen. Some fragments were angular, telling of late fractures; some were worn on the edges, telling of long exposure to the atmosphere; some were worn by longer time into three-sided boulders, resting on a still angular base, evidences of an unmoved condition for thousands of years. There were cracks on the surface rock, fresh and sharp, others with well-worn edges; the whole scene pointing to a long-continued, never-ceasing breaking up of the basalt surface rock under the never-resting forces of ordinary denudation; these were a hot sun, heavy rains, the growth of vegetation, acid percolations, and old Time.

Buddhists and Brahmins have been busy with these rocks for more than two thousand years; vast cave temples have been hewn out of their hearts by mallet and chisel; great shrines, full inside and out with strange figures, man's ideal gods and demons, satisfying for long years the human instincts of hope and fear, are carved there from the black basalt, the outward and visible sign leading the inner hearts of some to their unseen Bugwan, our God.

However antiquated some of these oriental customs may be, we cannot help respecting so long, so devoted a love; we cannot help seeing that it is the result of an early practical lesson inculcating a duty beyond which the simple wants of nations have never gone; the simplicity and the sameness run through the people. The man who gathers stones on the mountain brow now, the sculptor of idols now, and the priest who officiates at the shrine now, are the adopted or lineal descendants of those who did the same things thousands of years ago;

each man uses the same pattern of utensils, the same kind of water-pots, as were used in their beginning.

These men are full of their trade traditions. We asked them how these basaltic rocks were made: the ordinary reply was, "by the Bugwan." A spare, dull-eyed ascetic, in a small temple at a hot spring near Arawud, in the Syadra range of mountains, a solitary human being amongst the wild beasts of the jungle, replied to our persistent inquiries in oracular language, "Why do you ask? They are from God!—there is nothing new: the air, the rain, and the sunshine have formed these rocks. The surface of to-day is formed of what is, the surface of yesterday was formed of what was. The winds and waters convey to burial to-day; they did the same yesterday. There was purity in the beginning, there is impurity now; they have mixed, but they rise again: do you not see the sunshine, the rain, and the air? Be satisfied!"

"And this hot spring?" I asked.

"I have just told you!—understand! You eat and drink the sunshine, your blood is warm; the fish eats and drinks in the slow absorbing water, its blood is cold. The fish and you are of the earth, do you not return to it? Is she not a universal mother? This spring is warm, that river is cold, nothing is forgotten!" The old man stepped into his bubbling cistern, creeping close to his venerated cow's mouth, sculptured in basalt, to warm his shrivelled limbs in the offspring of the sunshine and the rain. We recorded his concentrated thought.

Wandering by the banks of Indian rivers, tempting the fish with the yellow fly, or stopping to examine the basaltic boulders strewed around thick as apples on the orchard grass after a September storm, the old question arose, Where did the basalt come from?

These water-worn boulders were very hard, but they were scratched or striated, and scooped out into great caldrons by the friction of sand and gravel washing round and round by water forces in their surface hollows. In quiet corners and on river beaches we found collections of fine black lustrous sand, remnants of the triturated boulders or of the basaltic river-bed: these sand heaps were collected and carried off to the city of Bhoranpoor for the manufacture of glass bangles. This finely-comminuted and well-washed sand could be carried twenty miles, and converted into glass, at less expense and less waste than the unbroken, unwashed, impure basaltic rock found on the spot.

We now knew that basalt was of the earth, the air, the water, and the sunshine. It could not have been without the three latter; it contained earthy matter that could be washed out by the water, or burnt out by the fire.

We thought of those early days when the first grasses grew on the first dry lands, when the Spirit of God, brooding on the waters, stirred up their lowest depths, not so deep then as now, forming from its pure silicious foundations a brighter mud than is formed to-day, and mixing these materials with the impurities of the first growths. We had read a dark link in nature's chain stretching in one unbroken line from the present, through the past, into the sunshine of the early earth.

> "From nature's chain whatever link we strike,
> Tenth or ten thousandth, breaks the chain alike."

No link was missing, the pure silicious matter of the Azoic had mingled with the impure burials of the Palæozoic epoch; materials so digested, so illegible, that the link could only be read by the context. These materials could be again eliminated from the purer matter by water or by fire. By the latter the silicious material could be converted into glass or lava, its earthy materials into ashes, and its water into vapour.*

* We have several times alluded to the fact that basalt, as we find it, contains in its constitution several substances that are lost to its products in a molten condition. The accompanying table may be referred to on each occasion. The first column shows a late analysis of a certain basaltic rock; the second shows the contents of portions of that rock. We do not mean to assert by this table that glass, slag, or lava, are formed from the rocks of the three first columns, but their analogies have been noticed before, and now we use them to exhibit discrepancies. These tend to prove that basaltic rocks, as we find them, could not have had their origin in fire. It is strange to read the arguments of learned men regarding the supposed recovery

By the former, the earth and water could be converted into mud, and the silicious material could be left as sand. It is allowed that basaltic formations were once in plastic conditions. If some of the constituents are lost sight of under the action of fire, we cannot allow that the plasticity was derived from a fused condition; but as the constituents are not lost sight of by the water process, we may assume that the plastic condition of the basaltic formations was as mud. We had the evidence of our own poor body to show the wondrous alteration made by the chemical laws of nature in what we eat and drink; we knew that the earth beneath our feet was composed, possibly of some ashes, certainly all of its own dust, multiplied and changed many times over by vegetation and life. We imagined that the contributions from the vegetable and animal kingdoms were not always so plentiful or varied as at present, and we gave nature the credit of carrying on God's "rule of law," in the dust returned to her, as it was carried on in the dust lent to organisms, for their moments, their days, their years, and their centuries.

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of lost substances by the basaltic rock after its imaginary molten birth. As they never could have been in a molten condition, these arguments may now cease, and we shall not again see a sentence like the following, that was once penned for our own instruction :—"Basalts like those of the Giant's Causeway cannot be distinguished from those of unquestionable volcanic action."—"Forbes' Athenæum," No. 2155. We ask, Where are they?

Minerals in Rossberg Basalt. — Dr. Petersen, —Geo. Mag., No. 117.	Analysis of Hydro-tachylyte and Tachylyte.	Rowley Rag Basalt. — Athenæum, No. 2153.	Glass. — Kane.	Plate Glass. — Dumas—Athenæum, No. 2155.	Blast Furnace Slag. — Athenæum, No. 2155.	Lava. — Silvester—Athenæum, No. 2153.	Lava. — Athenæum, No. 2155.	Absent from original rock before melting, or lost in that process.	Remarks.
Augite……	Silica………	Silica………	Silicic acid	Silica………	Silica………	Silica………	Silica.		
Olivine……	Lime………	Lime………	Lime………	Lime………	Lime………	Lime………	Lime………	Olivine……	This is a product of leaves and bark of trees, from Salicine.—*Kane.*
Nepheline…	Alumina….	Alumina….	Alumina….	Alumina….	Alumina….	Alumina….	Alumina….	Nepheline	
Titaniferous Magnetite	Magnesia…	Magnesia…	Magnesia…	…	Magnesia…	Magnesia…	Magnesia…	Titaniferous Magnetite.	
Apatite……	Ferric Oxide.	Protoxide of Iron	…	…	…	Protoxide of Iron	…	Apatite……	A phosphate of lime, or an earthy material of bones —*Kane* and *Page.*
A Plagioclastic Felspar	Ferrous Oxide	Sesquioxide of Iron	Oxide of Iron	…	Oxide of Iron	…	…	Ferric Oxide Ferrous Oxide.	
Leucite……	Potash…….	Potash…….	Potash…..			Potash …		Sesquioxide of Iron.	
Mica………	Soda………	Soda………	Soda………			Soda ……	Alkalis…….	Felspar…… Leucite……	Partly convertible into the silica or lime.
Melitite……	Water…….	Water… ….	…			†Water…		Mica……… Melitite……	
Hauyne or Nosean…..	Phosphoric Acid………	Phosphoric Acid………	…	Alkalis…….	Alkalis…….	…	…	Phosphoric Acid ……	The vegetable or animal constituents of rocks, when melted, would vanish in vapour, or resolve into ashes; while the metallic would naturally sink below the lighter lava and be lost, to the product of melting.
*Osteolite…	Titanic Acid………	Titanic Acid………	…					Titanic Acid ……	
*Zeolitic Minerals…	Manganous oxide	…	Oxide of Manganese…					Manganous Oxide ……	
…	Chlorine	…	Oxide of Lead	…	Other bases	…	Oxide of Iron	Hauyne or Nosean	
…	Fluorine	…	…	…	…	…	…	‡Osteolite ‡Zeolitic Minerals	Osteolite is from phosphorous existing in all animals and in a few vegetables.

* Products of decomposition. † It is quite possible that this water was absorbed by the lava after ejection. ‡ Products of decomposition.

As no two basalts could give the same analysis, so no two molten products could be similar. This Table shows that the formation of basalt is not due only to the Azoic epoch.—*H. P. Malet.*

As we read the changes in our own body by the context, we used that for reading the rock. We saw a grand sign-post on ocean's highway pointing with a sure finger to silicious and earthy mixtures, once held in solution, settling down as mud, and forming into the basaltic rock.

However easy it was to come to this conclusion, in the self-confidence of youth, with all nature fresh, fair, and unsophisticated before us, we are puzzled in our old age by the many sign-posts erected at every turning, all pointing to new paths for the same goal; set up, painted, and inscribed by men as confident in their local knowledge as we once were; each one pointing to the only direct road for the formation of basaltic mass and mountain height. The directions are clear and explicit, but all differ; they cannot all be right; there must be something mental and philosophic somewhere. We propose to walk into a few of these paths, with the hope of finding out the true origin of basalt. We look at the fair pictures by old Italian masters, we see a hundred St. Sebastians, we count thirty-seven Holy Families in one gallery; they are all ideal; none of the painters saw the holy family or the saint; they were all philosophers. We lately remarked to a noted sculptor that he must have had a charming model for a statue. "We improve on our models," was his reply. Are all the fingerposts before us improvements on nature's direction? are they mental pictures of basaltic origin and igneous causes?

The chameleon occurs to us here:—

> "When next you talk of what you view,
> Think others see as well as you."

So, without replying to that question, we place a few pictures before our readers, promising an acceptance of their decision if they can prove that any one is right. The galleries before us are very extensive, the pictures and the sign-posts very elaborate, very interesting. We cannot remark on all, we cannot do full justice to any, we only propose to notice a few pictures which have reference to our subject.

About the time that we were observing basalt in India, 1831 to 1839, Charles Darwin was sailing round the world in the "Beagle," preparing his "Naturalist's Voyage." His picture of molten rock mountain formation comes first on the list—

(No. 1.) "I believe that the solid axis of the mountain differs in its manner of formation from a volcanic hill only in the molten stone having been repeatedly injected, instead of having been repeatedly ejected."—*Darwin.*

The frequent injections were suggested by a desire to keep the earth in order, for the next picture shows—

(No. 2.) "If the strata had been thrown into their present highly inclined, vertical, and even inverted positions by a single blow, the very bowels of the earth would have gushed out."—*Ibid.*

We can only remark in passing, that if molten stone can be kept in conical, peaked, or in chain-like form, the gushing bowels might have assumed the same shapes; our mountains might have been larger than they are; we might have been freed from all anxiety as to more molten matter, but the precession of the equinoxes might have brought us into trouble. The next sketch shows that—

(No. 3.) "The Himalayas disturbed and bore up with them, in their upheaval, vast beds of the oolitic system. Belemnites and ammonites have been dug out of their sides along the line of perpetual snow, 17,000 feet above the level of the sea."—*Hugh Miller.*

This upheaval of a million of square miles by an unknown force did not seem so dangerous to Miller as the injection did to Darwin. We shall have something to say on its probability presently. We now enter a small, rich, introductory cabinet of geological subjects by Mr. Page, where we find that—

(No. 4.) "Basalt is of igneous origin, essentially composed of augite and felspar, with admixtures of hypersthene, hornblende," &c.—*Page.*

Mr. Page does not tell us how the constituents united, or how perishable and convertible materials endured the igneous origin. As his book is much used in schools, it might be as well to add a footnote in the next edition for the benefit of this inquiring generation.

We now step into a series of rooms called the "Geological Magazine;" in No. 114 we are introduced to mountains—

(No. 5.) "Forms of beauty, grace, and grandeur, which impress themselves in varying degrees of intensity upon our senses."—*H. Woodward.*

This is a frontispiece to a very beautiful portfolio which we shall have occasion to return to occasionally; at present, we select from its pages certain sketches—

(No. 6.) "Deposits, 40,000 feet in thickness."—*J. Hall.*

All of which can be elevated by

(No. 7.) "The theory of aqueo-igneous fusion of deeply buried sediments."—*Le Conte.*

If the heat is created by the buried matter there would be some truth in this picture, but this truth is disguised by the next—

(No. 8.) "At the depth of 40,000 feet, at an increase of 'about 90° per mile,' a temperature of 'nearly 800° Fahr.' would be found sufficient 'to produce aqueo-igneous fusion."—*H. Woodward.*

A certain depth for heat, and a certain heat for melting rocks, have been long desired data, but we are thrown into confusion again by the next sketch—

(No. 9.) "A small quantity of alkali in the included water of such sediments would melt rock at lower temperatures."—*Ibid.*

There is much truth in this, but the measure of depth is utterly lost, because alkali may be on or close to the surface. This sketch (No. 9) will be looked at again, but we walk on to another—

(No. 10.) "It is 'by no means impossible that in some cases the granite may be squeezed out as a pasty mass through a rupture at the top of the swelling mass of strata.'"—*Le Conte.*

We do not recognise any necessity for the strata to swell, but there is no doubt that granite, as cold mud, has been squeezed out of its original position. We shall come to the explanation of the phenomenon by and by. We now come to—

(No. 11.) "Such trivial modifications of elevation or depression as we see are, after all, only skin deep; they are but wrinkles left by the hand of time on the still fair face of mother earth."—*H. Woodward.*

This is natural and pretty; wrinkles are left by the sinking of soft, and the apparent elevation of harder matter; but as if we were hunting an igno-fatuus, instead of an aqueo-igneous, Mr. Woodward warns us not to accept an idea that has been "ably advocated" in England and America in pictures.

(No. 14.) "Of a slowly progressive subsidence over areas of accumulation occasioned by the weight of the slowly and successively accumulated sediments."—*Dana, Silliman, Ricketts.*

If this subsiding had been true, then—

(No. 15.) "'The solid mass of the Himalayas,' occupying some millions of square miles, must have sunk into the 'yielding crust beneath.'"—*H. Woodward.*

It would have been unfortunate if these grand wrinkles had vanished from our mother's brow, but we all know that there are soft and hard foundations. The Himalayas have the latter; but in volcanic regions, where there are several actions at work to undermine the strata, the mountains do subside, as they have done in the Andes and other places. Under a universal law it seems that old people and old worlds must have wrinkles; they seem to come quicker in both cases, where the fiercest fires burn, but quickest of all where fire and water combine to ruin the foundation—

(No. 16.) "Passing on to 'Geological Magazine,' No. 109, we find a picture of blocky rock surfaces formed by erupted volcanic masses, as 'the basaltic hills of the Siebengerbirg,' by shrinkage during consolidation, from a 'more or less pasty magma,' after 'a state of igno-aqueous liquefaction.'"—*Poulett Scrope.*

There is a great deal of nature in this picture, the *igno* being the only unnatural touch in it as the entire scene could be exhibited as an aqueous liquefaction. There is a difference of treatment of the same subject between M. Poulett Scrope and Captain F. W. Hutton. In "Geological Magazine," No. 115, we find the latter defending his sketch—

(No. 17.) "The 'deposition theory' of mountain formation, or the removal of matter from one place to another by lateral pressure."—*F. W. Hutton.*

We must come to this squeezing process hereafter, but there are etchings before us that we must look at. In "Geological Magazine," No. 116, the Rev. O. Fisher exhibits

(No. 18.) "'Damped paper stretched on a board,' as an excellent illustration of mountains."

Perhaps there is more truth in this than we can at present explain, but the artist gives us another illustration—

(No. 19.) "So long as the tracts of the earth's surface, which we compare to brick coping, are not too large in comparison to their thickness, and of sufficient homogeneity and rigidity to be fairly represented by a course of bricks laid edgeways."

This gentleman says, "I should much like to see a diagram showing a range of mountains formed on Captain Hutton's theory." So should we; but by the diagram furnished by himself, we do not understand how it is that our engineers have never yet hit off one of the tunnels that nature has left through the mountains, if the bricks on edge are correct likenesses of their formation. Mr. Fisher raises his mountains by pressure, in No. 115. Captain Hutton says—

(No. 20.) "Those areas should never rise at all."

We really think that mountains may be as liable to rise on Mr. Fisher's system as they are to be pushed aside by the system of Captain Hutton. These various theories all contain some truth in them which we hope to elucidate presently.

Keeping some of Mr. Woodward's rooms for our return, we now step into the treasury called "Principles of Geology," by Sir Charles Lyell, 2nd edition, 1872. The first picture is

(No. 21.) "The basalts of Hesse are of igneous origin." —*Raspe*, vol. i. p. 70.

(No. 22.) "The trap rock in the Vincentin analogous to volcanic products, and distinctly referable to ancient submarine eruptions."—*Arduino.*

Desmarest, Fortis, and others had

(No. 23.) "Established the relations of basaltic currents to lavas."

(No. 24.) Showed how "streams of basalt had poured out from craters, which still remain in a perfect state." —*Faujas.*

With so many verdicts in favour of fire, we do not wonder that the origin of basalt is assigned to fire. There are relations between basaltic currents and lavas. We know that lavas may be produced from, and consequently must be related to, basalt: basalt, therefore, existed before its lava. As a thing of itself, its origin from fire is by no means proved; and it is curious that none of these artists, if they are determined that basalt issued from volcanic rents, perceived that mud torrents could be ejected from volcanoes as easy as water, and that these muds when dry should be basalt. Looking to the opposite side of the room, we find a picture—

(No. 25.) "The basalts of Hesse, and all other rocks of the same family in other countries, are merely chemical precipitates from water."—*Werner.*

We are now in the arena where Neptune and Pluto became so celebrated a few years ago, till the latter claimed a victory. However, here is another noted picture—

(No. 26.) "In the primeval ages of the world there were no volcanoes."—*Ibid.*

Sir Charles Lyell gives these pictures a place in his gallery, but condemns Werner for overturning a true theory, pointing out in a lively sketch that—

(No. 27.) "The substitute was one of the most unphilosophical that can well be imagined."

There is more irritation in these words than the occasion justified; perhaps it did not strike Sir Charles that true pictures cannot be so philosophical as mental ones. We now open a portfolio by a very noted artist, the frontispiece is—

(No. 28.) "The ruins of an older world."—*Hutton.* Followed by

(No. 29.) "Basalt and many other trap rocks were of igneous origin."

Their different aspect from that of ordinary lava was

(No. 30.) "Attributed to their having cooled down under the sea."

To which is appended an experimental design showing

(No. 31.) "The crystalline arrangement and texture assumed by melted matter cooled under high pressure." —*Sir James Hall.*

On which we remark, that no experiment by man is a proof of what nature can do, the result showing only that silex was present in the mass experimented on. The Professor (Hutton) did not feel quite satisfied himself as to some points of his igneous theory, so he wandered to the Grampian Hills to seek for evidence in its favour. He soon found all he wanted, so he sketched

(No. 32.) "Veins of red granite branching out from the principal mass, and traversing the black micacious schist and primary limestone."—*Hutton.*

(No. 33.) "The alteration of the limestone in contact was very analogous to that produced by trap veins or calcareous strata."—*Ibid.*

He called these

(No. 34.) "The most clear and unequivocal proofs in support of his views."—*Ibid.*

"And," says Sir Charles, "this verification of his theory filled him with delight." The Professor was unable to fit his fire theory into the formation of the primary schists, so he painted them as—

(No. 35.) "Sedimentary rocks altered by heat, and originated in some other form from the waste of previously existing worlds."

We have nothing more philosophic before us than this portfolio. The old worlds, the granite veins, the alteration of calcareous rock by a supposed igneous action, are all mental pictures; cold silicious percolations may make the alterations; veins of heavy muds may run into softer. Hutton's discoveries may have been made in the same way. His fire is imaginary; and we have no occasion to seek in previously existing worlds an explanation of the phenomena we are incapable of comprehending in this. We are not geologist enough to be fettered by Hutton's dogma, and say that "we are in no way concerned about questions as to the origin of things." We do not wish to be antagonistic or a friend to either theory, but we do wish to discover the truth; and while we try to avoid the caution of the present school, which prevents their acceptation of things before their eyes, we will endeavour to steer clear of that rashness which has led so many geologists into the

(No. 36.) "Internal deep-seated source of heat, with which we are but little acquainted" (*Page*).

As well as into "speculations as to the interior of the globe, concerning which we can know nothing by actual observation."

Stepping back through some side rooms, where the curtains are partly drawn, we find in "The Interior of the Earth," published in 1870, a copy of a picture by Durocher, and some originals—

(No. 37.) "Whatever be the reason, it is certain that the basic rocks, whose eruption took place during primary geological periods, were formed merely by accident, as compared with the immense development of the silicious and felspathic masses."

This geologist perceived that the silicious rocks, of which basalt is one, were not erupted rocks, so we look at some originals.

(No. 38.) "Neither granite nor basalt in their original state were formed by fire."—*H. P. Malet.*

The next picture explains the subject more fully, and opens up a wide field of suggestions—

(No. 39.) "What has fire done upon earth? Fire has only destroyed and reconstructed. Nothing has found an origin in fire. Fire itself is an effect, and not a cause; it is in the atmosphere, it is in the flint of the earth, it is in the water—in each it is a thing by itself unseen or unfelt; certain conditions bring it into active existence."—*H. P. Malet.*

Passing on, we come to the latest pictures on the subject by the most accurate and most careful calculator of the time, though some of his studies from nature seem to us to be wanting in truth; the views we look at are drawn to meet certain objections, made by Mr. Poulett Scrope, to the grand design of volcanic energy by Mr. Robert Mallet.

(No. 40.) "If I have appeared to underrate the views of geologists as to the nature and origin of volcanic heat, it is because I believe them to be wholly untenable by the light of existing science."—*R. Mallet, Geological Magazine*, No. 117.

The views alluded to are the seas and lakes of molten lava kept in the earth's interior. We have seen, in picture No. 9, how Mr. H. Woodward left an escape for himself out of the fire world, and now he hopes to get Mr. Poulett Scrope out of the burning by noting on the sketch of R. Mallet, that Mr. Scrope has doubted the internal fluidity of the earth, and the access of water to that molten matter for some years past. We do not doubt but Mr. Scrope is as anxious to get out of hot water as Mr. Woodward is; but we refer both of them to the picture No. 16, while we find that Mr. R. Mallet, in "Geological Magazine," No. 118, tells the editor that his footnote does not seem "justified by facts." This molten interior on which so much depends, and on which most of the pictures selected by us are founded, seem to be a much more dangerous plaything than has been generally imagined. Here is its picture—

(No. 41.) "The flood of heat poured forth from such an incandescent nucleus through such a thin skin . . . would be such as to roast every organised being off the present face of our earth. Yet this gigantic incandescent nucleus and parenchymatous surface-skin, Mr. Scrope, and the school to which he belongs, must have, or their theories are impossible."—*R. Mallet.*

Mr. R. Mallet has very considerately supposed that we are 200 or 300 miles from the heated centre. We hope he is nearer the truth than picture No. 8 leads us to imagine.

We gladly step into the cool garden to think over these varied pictures of the same originals. Volcanic energy, molten mountains, melted basalt, mud basalts, other worlds, and sedimentary schists, flit before us in intangible conditions, like mock moons, or dancing reflections of the hazy sun. We cannot for a moment allow that any mass of rock, holding in its composition materials that are convertible by heat into other conditions, could have originated by fire.* By denying this origin

* See note, p. 179.

to basalt, the question of its origin expands itself. If basalt and the old silicious schists are water sediments, No. 35, or precipitates, No. 25, how were the solutions formed that left these deposits? We cannot draw lines too fine; a microscopical line of to-day may grow large by to-morrow. Nature is composed of fine distinctions, shown nowhere more clearly than in the perpetual changes in the character of her volcanic ejections.

Lava is formed from the indestructible base of the rocks that furnish it. Lava is of varied qualities, consequently the rocks that give it must be formed of varied materials. Looking back on the cosmical supplies of matter, we come to a time when they were not so plentiful or so varied as they now are. The area of land was not so extensive; the waters were more extensive, but not so deep; all the productions of either element were liable to greater trituration, and more complete defacement than at present; the winds were more unbridled, the waters were more uncurbed, organisms were fewer, therefore fewer were preserved in recognisable conditions. As the greater part of present growths return to undistinguishable dust, so they must have done at all times; as these dusts are now left alone, or carried away, arranged, and buried by wind and water, so were the dusts of old. Under the unavoidable law of nature, we thus fall in with the origin of Hutton's sedimentary schists, and Werner's precipitates from water, as ordinary formations from the dusts and muds of primary matter, mixing with the dusts and muds from the early growths of this world, all of the materials in unrecognisable conditions, all altered from what they were, all beautifully preserved in a magnificent mausoleum, but all liable to be again converted into muds and dusts, for new constructions by water; or, if acted on by fire, to separate and fall to pieces, converted, in their perishable atoms, into vapour and ashes, while the unperishable silicious atoms may melt into the analogies of glass, lava, or slag.*

While thus dreaming on, we reach an open, dome-covered building; its ceiling was beautifully painted: mountain and valley, rivers and lakes, wide plains, and a wider sea filled the roof; there was no horizon; water, earth, and their vapours mingled with the haze of heaven till it cleared off into the blue vault of the zenith. The interminable space was to us as a type of the immeasurable past. Men have tried to fathom that without success; we do not attempt it, but we find on a basaltic slab an exquisite leaf of Owen's "Palæontology," leading us to an authentic knowledge of ancient life, and showing—

"That from the inconceivably remote period of the deposition of the Cambrian rocks, the earth has been

* See note, p. 179.

vivified by the sun's light and heat, has been fertilised by refreshing showers, and washed by tidal waves; that the ocean was not only moved in ordinary oscillations, regulated, as now, by the sun and moon, but was rippled and agitated by winds and storms; that the atmosphere, besides these movements, was healthily influenced by clouds and vapours, rising, condensing, and falling in ceaseless circulation. With such conditions of life palæontology demonstrates that life has been enjoyed during the same countless thousands of years; and that, with life from the beginning there has been death." —*Owen.*

It is still the opinion of many excellent men that no death of any sort happened in this world till "death came by sin"—*i.e.,* till after man was born; but what connection man's death has with that of a lamb or a blade of grass it is for such men to explain—the whole system of the earth shows that this orthodox idea is an error in its abstract sense.

We are told by Page that the Laurentian and Cambrian systems are "the lowest fossiliferous formations yet discovered in the crust of the earth." No one supposes that amidst these remains we have discovered fossils of the first creations. Life came by slow degrees, it increased and multiplied; the first-born are recorded as dust, mixed up in the illegible rocks of these systems: while in and below them must be the equally undistinguishable remains of the vegetations prepared for the maintenance of the first lives. As the dusts of these vegetations must have been as liable to ignite, to expand, to give out their vapours, to leave their ashes, and to separate from their silicious masses, as the dusts are now, how is it that, though reposing on the very confines of the supposed flaming interior, their silicious portions were not converted into lava, or into the supposed igneous rocks—basalt, trap, and all their varieties ?

Leaving this question unanswered, we will briefly follow Mr. Page through the systems of this earth, as arranged by him, and accepted by our schools, with the intention of finding out where certain igneous action is proved by the results.

SYSTEMS BY PAGE.

Metamorphic.—The lowest stratified system of the Azoic or lifeless epoch is called the metamorphic ; in it are "gneissic and granitoid schists"—composed of "felspar, quartz, mica, talc, hornblende, and chlorite—these ingredients having been originally deposited as silts, and muds, and sands."

Laurentian contains crystalline schists, quartzites, and serpentinous limestones.

Cambrian contains semi-crystalline slates and schists.

Silurian contains shales and limestones, grits and flags.

Old Red Sandstone.—Yellow and red sandstones, and conglomerates. In these two systems supposed igneous rocks appear as "overspreading or molten lava," or as "scoriæ and ashes," also as "upheaving or disrupting masses, cut through by dykes of greenstone, felspar, and porphyry, seemingly indicating a cessation of volcanic action, during the main deposition of the old red sandstone, but a period of great activity and disturbance, both at its commencement and its close."

Carboniferous shows "ample evidence of igneous activity," traps and basalts are plentiful, "upheavals and convulsions" numerous.

Permian has "dykes and outburst of basalt, which seem to be connected with igneous centres situated in the older systems."

Triassic exhibits similar conditions.

Oolitic shows gentle "outburst of trap" and dykes of greenstone.

Cretaceous has no igneous rocks in England; but the basaltic crags of the Giant's Causeway in Ireland are supposed proofs of igneous action there.

Tertiary.—All the igneous rocks of this system are of "true volcanic origin . . . with the exception of a few doubtful cases."

Post Tertiary, including the present, gives us plenty of volcanic action producing lava, as the melted matter issuing from granitic or basaltic rocks. Neither of these rocks are now reproduced by igneous action in their normal condition.

According to these arrangements of science, we have evidence of igneous action in the two upper systems, down to the Silurian, but none in the systems below that. On this *primâ facie* evidence, we answer that the silicious masses at the bottom of the stratified systems were not converted into lava, because there was no fire below them. As this answer coincides with the laws of nature, we leave it for a moment to consider another point connected with the basaltic rocks as we generally find them. Mr. David Forbes told us in the "Athenæum" of 13th February 1869, that one lava is strikingly analogous to the old granites in chemical composition, and the other "nearly, if not quite, identical with the basalts." Also that portions of a mass of Rowley Rag Stone that he melted, when cooled, "could not, even upon minute inspection, be distinguished from the original basaltic rock." We take these facts as direct evidence that basalt existed as a rock before the experiment or the analysis were made. We allow that nature can do what man does, but the conditions must be identical in both cases. To enable nature to turn a basaltic rock into a molten mass, and back again without alteration in its features, we must find the rock in strata without gas or water; the expansion of one, or the explosion of the other, would necessarily destroy the identity of the experiment and its result. This condition could not be found.

We were told in No. 8 that 800° Fahr. might produce fusion of rocks, but Kane's "Chemistry" (p. 56) tells us that 1000 volumes of air expanded to 23,125 at a heat of 660° Fahr.! We can say little about water at present. Kane tells us that according to the supposed progressive increase of heat, as we descend in the earth, water could not exist as a liquid at a depth of two miles (p. 105). Under no circumstances could Mr. Forbes, or those who have conducted similar experiments before him, place nature in a condition similar to themselves; the expansion of the buried and imprisoned gases would have converted rock and experimentalist into some other materials. One point is, however, gained by their labours. As the basaltic rock existed before it was melted, so it must exist before any basaltic lava is produced. The molten produce of any silicious material must be analogous to our varied glass, to the slag of our furnaces, to the vitreous productions of our kilns, to the glassy streams which ran from the decomposed granite pillars during the late fire at Boston, as told by an eye-witness, and to the glass bangles produced from the basaltic sand at Bhoranpoor. These products lose some of the impurities of the material from which they issue; none of these impurities could be restored by fire; the rocks could not be reconverted into their normal condition under any action of natural combustion. So that there is *primâ facie* evidence to show that the basalt rock, as we find it, full of its native impurities, never was in a fused condition.

CHAPTER XII.

BASALT (*CONTINUED*).

We now come to outbursts, upheavals, and overspreading molten matter; to these we join subsidences. None of these actions are directly related to the origin of basalt, but all of them are directly related to the varied conditions in which this rock appears before us. It is allowed on all sides that basaltic formations must once have been in a pasty or a fluid condition. We are told that the hard schists were deposited as mud or silt. If the silicious materials, of which these schists are composed, were capable of being converted into mud, how much more easy must it have been to make muds out of these schists, when it came to their turn to be reconverted into solutions, to mix with the increasing soft materials, all ready to form another mud. Mud has not been an attractive subject, our science gets rid of it as soon as possible, yet the phenomena connected with it are very numerous, very interesting, and all-important to our present subject. On looking along our sea shores we find frequent subsidences of upper earth-masses into the soft mud or gault below. This gault is pressed or injected into the fissures of the subsiding mass, it is forced into the shape of pillars and dykes, and it is squeezed down through the ordinary water-runs beneath the sands, where we find it as thin interstratifying sheets. When the overlying sand is incapable of resisting the force of the pressure, it is forced up into banks or ridges, parallel to the line of subsidence. If the muds of to-day are liable to these actions, there is no reason why the muds of old should not have been under the same law. Thin sheets of interstratified basalt have lately been found in Ireland. There may be differences in the constitution of the mud, or of the overlying and subsiding strata; but the law of gravitation is the same; so that if the mud or silt is unequal to sustain the weight of any overlying matter, then that matter must of necessity subside into the mud, and the mud must give place to weight.

Subsidences, therefore, do take place; they do force liquid, or plastic mud, into overspreading sheets; they produce upheavals and outbursts of the mud into every possible shape allowed by surrounding matter. To this unavoidable system we owe the convulsions, the fractures, and the condition of many of our mountain masses. The cessation of volcanic action during the old red sandstone system was purely imaginative on the part of Mr. Page, but it will be obvious to any one, that where sand was in course of deposit, mud could not be; so that the subsidences and their results did not take place. We will not be so dogmatic as to say that the Giant's Causeway is due to cold mud and pressure; there are many similar formations about the world, and if we allow that basalt ever was in a plastic state, there is no reason why it should not have assumed the columnar and prismatic form under a cold as well as under a molten condition. The crystalline condition of these columnar basalts has been brought forward as proof of igneous action. We have given good reasons why basalt, as it is, could never have been in a molten condition, and crystallisation is only a proof of the presence of silex.

It is a well-known fact that basaltic lava retains its heat longer than other lavas, but it has been a matter of wonder how molten basalt could have retained its fluidity, so as to run over many hundred square miles. We do not suppose that the great basalt sheets of America or of India ever were molten; but if they were formed of mud, then there is no limit to their extent, as long as the supply lasts.

Having thus briefly vindicated the law of gravitation, we have now to consider the results of contact between certain rocks. Hutton jumped to his conclusions because he wanted them; he had formed his theory before he went to the Grampian Hills, and he assumed that veins of one rock permeating another gave evidence of a melting process. No one has explained how this permeating action was carried on, and we are at a loss to understand how a soft molten matter could run into an unmolten rock. There is nothing in the laws of nature whereby we can solve this point; but there is a law under which the whole process is done without fire, and in default of any fire examples we may fairly assume that the granitic veins of Hutton were formed in the same way.

It is a very common occurrence in the fine sandy formations of eastern rivers to find veins of one colour and one character running into masses of other characters and colours; the heavier muds run into their lighter neighbours, assuming every variety of figure. The same results may be seen in English clays. Marbles are evidences of the same thing; so that, under these actions of the law of affinity and gravitation, Mr. Hutton's veins required nothing out of the way to place them where he found them. On looking at calcareous rocks in many parts of the world, at slates and schists, we have seen that the silicious matter frequently runs from one part to another. In the Isle of Wight great masses may be found into which these percolations have taken place; by which portions have become so indurated as to withstand the ordinary denudating causes, and remain as hard rock after the destruction of that portion from which its silicious matter came. The same action is evident in the schists, where the silicious matter has run from one part into another, forming veins in one portion, and crystallised blocks in another. These are only different results of the same law exhibited in chalk, where the silex percolates from the sediment, forming a layer of itself; as no one supposes this is done by heat, so there is no proof that heat does the others. Fire is not needed for the petrifaction of wood, for the conversion of sponge into flint, or for the formation of agate; they are all cosmical alterations of matter due to the laws of affinity and gravitation. As fire is not wanted for the alteration of rocks, for subsidences, or upheavals, for injections, squeezings, or contractions, or wrinkles, though it may lend a hand to each, or to all, we have now to show how true igneous rocks, such as lava, are connected with fire.

We have strolled on towards the carriage entrance of the gardens. Wide verandahs occupy both sides, their walls are covered with bold frescoes of extinct volcanoes. Auvergne and the Venetian Alps are there, with no more fuel to keep up their once volcanic energy. The depths of the supposed fires are exhibited, according to fancy, as eight miles deep, twenty-five, thirty, one hundred, two or three hundred, two thousand five hundred, and the precession of the equinoxes goes on, without any reference to these diverse conditions, with its ordinary regularity. We think of the bold paintings of the infernal regions on Italian cupolas by artists dreaming of Dante or of Virgil. We see that the world goes on in its goodness and its wickedness just as it did before Virgil or Dante lived, and we recollect that no poesy, no philosopy can alter the laws of Heaven or of earth. In a dusty corner we find a design of Sir Humphrey Davy busy with potassium and sodium, his attendants are loading a van with alkalis; the coachman is ready to drive it round the world, to show the causes of subterranean heat and volcanic action. "Silica, alumina, lime, soda, and oxide of iron, substances of which lavas are composed," were all packed as evidence of the action, but, at the last moment, Sir Humphrey found that the horse "Hydrogen" would not come out of the Vesuvian stable. The team was incomplete, dust was thrown over the van, which became neglected in the corner. It is, however, shown that M. Abich "clearly detected the flame of hydrogen in the eruption of Vesuvius in 1834;" but Sir Charles Lyell had thrown a veil over the van and its load. If it had been brought out then, it would have caused much inconvenience; there were a great many emblazoned chariots and fiery steeds on sale, or likely to be on sale about that time; so, not content with the veil, Sir Charles borrowed a patent break from M. Foquè, who was "satisfied with the hypothesis of a subterranean sheet of fluid lava, to which water may occasionally gain access, central heat being invoked as the power by which the lower parts of the earth's crust are retained in a melted state," and who considered the quantity of "alkaline metals beneath all the active volcanoes, which had given rise in each to a long series of eruptions, would be incredibly great." * M. Foquè had the audacity to measure by human finite figures the infinite results of laws which rule this globe; he put down the quantity of sodium required as at least "7,000,000 cubic metres." With the help of this patent break the chemical van was immovable; Sir Charles in his mechanical light phæton got to the bottom of the Andes, and other places of active volcanity first; he found that the existence of fused lava "cannot be doubted," so that his wheels have revolved well up to this time. We now consult him and others about the incredible quantity of sodium.

"Sodium exists in great quantities in the mineral kingdom. . . . Enormous deposits are found in England, Poland, and elsewhere;" it is "the leading saline ingredient of the waters of salt lakes and of the ocean." If it exists in places we know of, we may give other parts of the earth credit for containing some of it. Sir

* See the Finite Figures of Physical Science, p. 173.

Charles Lyell tells us that "140,000,000 yards of lava were ejected from Etna in 1669; but this quantity was not equal to one-fifth of the sedimentary matter which is carried down in a single year by the Ganges." Can any one estimate the quantity of sodium carried down in one year, from the animal fluids poured into this river from its populous banks? Again he says, "51,321,600 cubic feet of earth are carried off by the sea yearly from Holderness," and "one characteristic of the action of currents is, the immense extent over which they may be the means of diffusing homogeneous mixtures." There is no area of land that does not contribute to rivers some of the rain which falls on it. Sodium is perpetually increasing: it is impossible to estimate the quantity of it contained in the vast masses of earth yearly handed over to the sea, to compute the quantities passed to the ocean by rivers, or to calculate the places where the currents will gather the sodium together as sedimentary matter in the ocean. We are obliged to Sir Charles for enabling us to say that M. Foquè's "incredible," as applied to the results of natural laws, only stamps his followers with credulity; while if we depended on sodium only as the chemical cause of volcanic energy, we should be depending on a source of matter which is beyond the reach of measurement or of computation, and consequently capable of producing immeasurable results.

We have shown above that, in the recent or post-tertiary system, all the volcanic products are lava; in the tertiary nearly all are of true volcanic origin, below these no lava is found till the silurian system is reached, while below that there is none. As the chemical causes for the production of fire and heat within the earth must be constantly increasing with vegetable and animal increase, we may say that the situation of lava in the subterranean regions is a *primâ facie* evidence that it was not melted by heat coming from below the sedimentary schists; while the present situation of lava on the surface is a proof that the heat is caused by chemical action in the deposits of the earth. So that No. 26 may be a true picture, and No. 9 may have a greater range than Mr. Woodward supposes. We have, however, something more to say of local heat before we can say that the theory of Sir Humphrey Davy is an absolute certainty.

Passing back by the other side of the gallery, we find some interesting sketches taken by Sir Charles Lyell, while travelling in his light phæton over the very causeway on which he thought it necessary for Sir Humphrey to use the skid.

(No. 42.) Hot springs are important to geologists, for the "quantity and quality" of the earthy materials thrown up.

(No. 43.) "Carbonic, sulphuric, and hydrochloric acids, combined with bases of lime, magnesia, alumina ; and iron, chloride of sodium, silica, and free carbonic acid, as well as nitrogen, are commonly present."

We cannot help wishing that Sir Charles had devoted a little more time to these quantities and qualities, for it must must have struck him as strange, that waters having fallen in with one heating cause, in some unknown place, should fall in with another before reaching the surface ; but Sir Charles had no hesitation, he drove on—

(No. 44.) "When new combinations take place, some of the gaseous, earthy or metallic ingredients of the springs may be intercepted in their upward course."

We consider this picture and No. 9 to be of the same school; and we venture to place the artists among the first philosophers of our times, in finding out that water became heated in subterranean regions by an unknown cause, before it ran up hill, on purpose to find a well-known cause of heat. We do not quite understand what is meant in this picture by "new combinations;" some must be for ever forming; but we have no occasion for them while old combinations produce hot water.

(No. 45.) Hot water is abundant "in regions where volcanic eruptions still occur."

The scene is true to life ; the mountain vomits spasmodically; the hot water runs out constantly; it is assumed that the igneous causes are the same for both The volcano dies away, the spring runs on; the origin of heat cannot be from the same place; because if one died so would the other; but as both fires were fed from the surrounding strata, it follows that the slow eroding water has not used up its supply, while the fiercely eroding volcanic fire has used up all the igneous causes available to it. We find as we wander back some little sketches that will make the subject comprehensible.

(No. 46.) "The mineral springs of Cauquenes burst forth on a line of dislocation, crossing a mass of stratified rock, the whole of which betrays the action of heat."—*C. Darwin.*

The character of this rock is not given, but heat is shown to be in the region—

(No. 47.) "Two springs a few yards apart with different temperatures, the lowest with scarcely any mineral taste."—*Ibid.*

The taste is some proof of heating cause, so that the less mineral, the less heat; but

(No. 48.) "In both these springs—in summer the water is hotter and more plentiful than in the winter." —*Ibid.*

Darwin pondered over this unavoidable result of a natural law, till he found that

(No. 49.) It "can only be accounted for by the melting of the snow . . . on a range of snowy mountains three or four leagues distant."

It was considered "a very curious" phenomenon, and taking it as he painted it, there can be no doubt of its curiosity, or of its philosophic character—

(No. 50.) "We must suppose the snow water, being conducted through porous strata to the regions of heat, is again thrown up to the surface by the line of dislocated and injected rocks at Cauquenes, and the regularity of the phenomenon would seem to indicate that in this district heated rock occurred at a depth not very great."

As far as nature is concerned, the phenomenon seems simple and beautiful. The melted snow percolating the earth finds in it causes of heat, and its level through the Cauquenes stratified rocks, which betray the action of heat. As there is no melting snow in winter, there is a smaller issue of water; as its subterranean erosion is not so great as in summer, the mineral taste is reduced as well as the heat. The only curious part of the phenomenon is, that the naturalist of the "Beagle" should have imagined any necessity for "thrown up water," when he saw that it was running down from the mountains. We look into our own pocket-book for a similar case—

(No. 51.) "At Wuzerebai, near Tanna, Bombay, a number of hot springs, of varied temperature, rise by the side of or in the river-bed: when the river is clear, these springs are clear; when the river is muddy, the hot springs are muddy."

The river waters find access to igneous matter on levels above these springs, that is, they run through strata containing the alkali of No. 9, or the metallic ingredients of No. 44, issuing from their different springs at temperatures due to the varied strength of the igneous causes they met with, or to the distances from the source at which they met them.

If we now look at the chemical theory of heat suggested by Sir Humphrey Davy—if we accept No. 40 as evidence against a molten condition of the interior, No. 26 as a dogma against the existence of primeval volcanoes—if we consider No. 44 and No. 9, we shall comprehend that the production of heat in the earth does not depend on depth, but on causes which may exist in any strata, as allowed by opponents of the chemical theory. There can be no error in this theory; there is no break in the system since it first began; it is conducted by natural laws from which there is no escape; its action is universal, but never similar. A great deal might be said here on the combination or constitution of bodies, as well as on atomic theories. The subjects would lead us into boundless worlds, while all we wish to impress is, that whatever deductions we make from pictures or from facts are made on long consideration of nature's laws. They are all cosmical; their results are unavoidable, as every result must be emanating from laws formed by one Almighty Ruler. Man with his finite capacity has been unable to measure God's infinity; the for-ever-varying quantities and qualities of matter are not understood; Baron Richthofen has slightly touched upon them, but the subject is almost too extensive for one lifetime to see. Man cannot estimate the heating causes in his own body; he does not comprehend its wondrous chemical changes. Failing in these, it need not be wondered at that he denies to his mother earth the very qualities she has bestowed on him. We are fond of the miraculous and the unseen; the savage adopts his fetish as a god; and we, in seeking for causes of heat in this earth, have adopted the most prodigious theories. Our geological school began its career with caution and observation for its watchwords. We walk through our gas-lit streets, we sit by our warm fires, we travel round the world by the aid of igneous action, gases explode in our mines, cargoes ignite in our ships, we strike a light from the flint, we create heat by the mixture of water and matter, we ignite air by pressure; all these are results of cosmical laws—the heat and the cold, the air and the water are never forgotten, never lost; something of everything that ever was is in the earth beneath our feet; the sunshine and the atmosphere are buried there, and while we daily use them, our schools have built up great structures from causes which they have not observed. If they wish to retain the confidence of the thinking part of the great communities around them, they must reconsider the cause of heat in the earth.

We have wandered through long galleries of fair pictures and notable sign-posts; each finger has pointed out its own path, every picture has represented the mind of its author as truly as the Holy Families represent the minds of Raphael and Sarto. It was not too great an undertaking for them to portray their comprehensions of heavenly gifts, it has not been too heavy a task for others to give us their interpretations of the universal laws; we may admire the pen as much as we do the pencil, but while we look at the pictures, our thoughts run back to the sunshine of our oracular Brahmin.

The air, the rain, and the sunshine have formed these rocks; the glisten of the silex tells of the pure beginning, the dark materials tell of the impurities it has mixed with. We can trace the pure matter from the silicious schists of the early days into the covering of the diatom and into the blade of grass; it is the cement and the girder of this earth, it saturates the sponge and the wood, it mixes with all matter, it percolates through the hard rock, and runs through the cretaceous formations; it is hard, it is gelatinous; in early days it formed rocks with scanty mixtures, in later days it became scantier itself; but with all the impurities mixed with it, basalt still holds some 50 per cent. of silex. These cosmical labours of mixing and reconstructing have been carried on in one unbroken chain formed of most minute links, from the beginning; in the midst of them our basalt tor and peaked spire, the mountain range and overspreading masses, the prismatic column, vertical and horizontal, the dykes and blocky surfaces, stand up before us as the sign-posts by the side of ocean's highway, self-evident proofs of a mud origin, self-evident contradictions of a fire origin, but containing in them such well-digested matter that it can only be read by the context, as the tree is known by its fruit.

There is nothing new, nothing wonderful, but there is something very venerable in the subject before us. We fall in with a perpetual resurrection of old matter; the farther we look back, the more pure it becomes; buried air and buried rain, bright silex, each at work, great examples of never-ceasing labour, all constituting the earth and the waters in the earth; the whole carrying out the orders of the universal Lawgiver; all so long at work, that wrinkles have been left on our fair mother's brow, formed by the sinking of soft matter by the side of the harder matter. These have remained as they are, evidence of the labour; those have been reconverted into mud for future construction. In these constructions there must be increasing causes of local heat; in the cosmical labours there must be subsidences and risings—the latter cannot be higher than the former can sink. This part of the subject belongs to our mountain formation; we have used it only so far as it helped on our origin of basalt.

Well may the clear-sighted Werner have declared that basalts were precipitates from water; bravely and truly may he have said, in the face of opposing philosophy, that in the primeval world there were no volcanoes. The unwilling Hutton, and many others, have unknowingly given evidence of the truth of this much-abused dogma. Their sedimental schists rest on the face of what they supposed to be a fire-globe; a globe supposed to be now in a cooling state. If in this condition it is still hot enough to keep up old and to create new volcanic energy, how much hotter must it have been when these schists were deposited by water a few hundred million of years ago, with nothing between them and the seething interior. Yet these silicious rocks were not converted into lava, neither were their earthy impurities separated from them. This separation of matter from the molten lava is now the great criterion of melted silicious rock,* and the lava is the

* See note, p. 179.

only true result of the volcanic energy. If basalt was ever erupted as a molten matter, why is it not erupted now?

In thus connecting lava with local fires of chemical origin from earth's deposits, we relieve basalt from a fire origin, while we provide something for the fires to feed one. We see the resurrection of the fuel; the sunshine is exhibited in flame, the rain in vapour, the air in the expelled gases, and the surface matter of yesterday, the illegible dusts of old time, are shown to us in the ashes, the erupted rocks, and the expelled mud. The earth is an old mother, she never forgets anything. In these wonderful resurrections she shows us the great facts of former existence: the purity of the silex is exhibited to us, it is sent up again to be reconverted into dust, into gelatinous matter, to be again the covering of a grass stem, or to mix in all organisms on the face of this earth; once more to mix with all impurities, and to be buried again—every time with an increasing cause of heat, for this is a heating globe, and not a cooling one!

Was the old man of the Syadra Mountains right, were his concentrated thoughts of planetary influence and elementary action as producing cosmical effects properly expressed? Had he in his solitude read nature's laws from nature's page? If he was right, if we have sufficiently explained his meaning in the mutual relations of the elements to basalt, it must be recognised as a great sign-post on ocean's vast highway.

The rock is before us to answer for itself, its impurities are still as soluble in water as they were when it was deposited by water; these impurities are still as convertible into other materials as they always must have been under the influence of fire, while its pure silex is still there ready to be separated from the impure by the heat of an artificial or a natural furnace.* As the tree is known by its fruit, so we know the basalt by its results. If fire separates its constituents, it did not originate from fire. If some of its constituents are soluble in water, it is made by water sediments; these sediments were formed of the surface matter of yesterday, the dusts, perhaps the ashes, of what had grown on the earth, watered by the rain, nourished by the air, and warmed by the sunbeam; not a primeval rock, but a daughter of time.

In raising our sign-post, we have used with some familiarity those whom we have met on the same road; we have intended no more disrespect to them than we do to Raphael, while gazing with admiration on his Holy Family, and dreaming, in love, of the pure original. We believe the goal of our fellow-travellers is truth; there can be but one road to it. We desire no controversy

* See note, p. 179.

on minute points. If any one can prove the existence of an internal fire down below the deposits of earth and water, we will accept the admirable dogma of Professor Tyndall, allow that our origin of basalt and our chemical heat are only mental pictures, and endeavour to philosophise over the unknown fuel of the interior of this earth. Till such proof is brought forward, we claim Werner as our guide, and Sir Humphrey Davy, with a few others, as our porters in search of the buried sunbeams in the gneissic schists of our mountain-tops, and of our lowest deposits, testified to us in the light given out by the mineral oil from the lamp on the table before us, and exhibited to us all round the world in all deposits, as well as in the basaltic rock.

CHAPTER XIII.

DUST AT HIS PHYSICAL LABOUR.—GRANITE.

If the labour of forming granite was as difficult to dust as the comprehension of it has been to man, it was one of the most arduous tasks that fell to the lot of our hard-working family.

That careful geologist, Mr. Ansted, told us that granite "is composed of variable proportions of felspar, quartz, and mica," varying in the size of their grains from minute atoms "to several inches in length," while the mica "is found in plates upwards of a foot square." Sometimes the quartz is separated in large masses, and some granites, not being so perfectly cemented, disintegrate more readily than others. "Granite occurs in almost every mountain district in the world," and is found in many regions on and below the surface-level.

Granitic quartz contains silica "nearly pure," felspar has "66·75," and mica 48·00 of silica; if hornblende is present it contains 48·08 of silica. Silica, then, is the main ingredient of granite, but it has in it alumina, lime, potash, magnesia, oxide of iron, oxide of manganese, and water; the quantity and quality of these constituents vary in every locality.

The amalgamation of these heterogeneous materials has been supposed, by many of our trusted geologists, to have been caused by heat. Granite is, therefore, classed with igneous rocks.

Under no conditions can granite in its coarse, or in its finer states, as syenite or gneiss, be a primary rock; its constitution is evidence that it is formed from materials that had a prior existence.

When we understand the mechanical arrangements of cosmical dusts, under the never-ending action of the cosmical agents; when we comprehend the cohesions, adhesions, the permeability and impermeability of our family; when we see our uncounted system of crystallisation; know that every crystal was at one time in a state of plastic liquidity; and when we see those crystals forming, by the combination of water and silica, in cold conditions, we cannot but admire the wondrous complexity of results, the extraordinary combination of material and force, the smallness of the atoms used, the precision of assortment, and the for-ever fickle forces of air and water, reducing all dusts, in all conditions, to obedience.

We have said so much about the law before, and we have so much to say about it again, that very few words will suffice to show how granitic rocks come under the ordinary cosmical system of water-formation. It is allowed that heat and cold produce elemental circulation and force in all its gradations; that correlative dust may be moved by relative forces. It is also allowed that we dusts may gravitate, or settle down by our own weight and character. We carry this capacity into our vapoury and soluble conditions. These solutions and vapours have, then, the power of gravitating in every situation that offers the opportunity. The actual condition of most rocks proves the degree of, or the absence of, force used in their construction. Granite, except where it is found in a stratified form, testifies to the peculiar method of construction. Leaving out all stratified formations of granite, syneite, or gneiss, every other granitic formation seems to be formed of granular crystallised atoms broken off from a more ancient rock, these atoms exhibiting, more or less, erosion of their angles, either by rolling together or by being washed by a water-force. In whatever condition these atoms are brought together in a consolidated condition, they are cemented together by silicious cement. The manner of formation may be in more ways than one, and the degrees of solidity may give evidence of the manner of formation.

The first method of formation is sub-ærial; that is, the rolling down from high places of silicious rock-fragments. In the act of falling these fragments break up into all sizes: the large masses roll the farthest, while the smaller atoms rest in all inequalities of the surface. Under this system of gravitation we find great accumulations of coarse conglomerate, far down the mountain-side, finer collections higher up, and the finest deposits nearer to the site, from whence all the fragments started.

In breaking up, in rolling down, and rubbing together, these finest atoms become more or less worn and rounded. The deposits of these small atoms extend to several hundred feet in length—to large or narrow breadths, according to the locality, with a depth varying with the undulations of the mountain-side. We have seen them filling up hollows of fifty or sixty feet, high up on the slopes, while the larger conglomerates are quarried to far greater depths; the whole having fallen from high places.

These coarse and fine conglomerates are firmly cemented together. In all positions these formations are unstratified. The rain falls upon these sub-ærial deposits, and the water-shed from higher sites runs through them. As the whole mass is more or less impregnated with liquid or pasty silica, it is acted on by the freely percolating water; it is spread through the mass, forming the cement, which binds the crystallised atoms to one another, filling up with its own pure crystallisations all unoccupied corners, running into lines and patches, and, according to its liquidity, leaving some of these granitic formations easier of disintegration than others.

The second method of preparing granite is by water. Taking the bed of a mountain-torrent as the scene of action, and going back to those times, when the matter, subtracted from the mountain-tops, consisted of silicious masses, we have a great amount of material handed over to the water-forces. In the act of rolling down the torrent similar force working on similar material for similar distances must bring a quantity of atoms together correlative to the same force. These atoms are deposited in convenient places, along the course of the torrent, in small or large masses, of coarse or fine condition without stratification.

In these conditions each mass becomes liable to the percolation of water, with exactly the same results as in the first position. An unstratified water-prepared granite is thus deposited by natural laws and forces. Depending on the original silicious deposits on our present high lands, and on the forces to which their fragments become liable, we have granitic rocks of varied colour, and varied size of grain, containing the ingredients mentioned by Ansted, and fulfilling all the conditions found in all sorts of granite rocks.

While we were digesting our notes on this rock, we came across two microscopical examinations of granite.

One in England by the Rev. Magens Mello, the other in France by M. Michel Levy; both are believers in the fire theory of granite origin, while the facts disclosed by both tend to prove one or the other of our systems.

We take Mr. Mello first, quoting from Hardwicke's "Science Gossip" for May 1876. Granite quartz contains "the metalloid silica and the gas-oxygen." The silica is correlated to "the flint of the chalk . . . the white veins in slates; our most beautiful agates, crystals, and precious stones are varying forms of the same substance; the skeletons of sponges, the valves of the diatomaceæ, and other minute specimens of organic life, consist of this very silica. . . . This quartz is not crystallised in definite forms as are the felspar and mica; it appears as a matrix, which has been at some time or another soft, and so is penetrated by the other crystals. . . . This shows that it must have been solidified after them. This is a very remarkable fact, and helps towards the secret of the formation of granite." We then find that "quartz requires a higher temperature to melt it than does the felspar or mica," consequently, if the granite had been formed in the ordinary way of igneous fusion . . . the quartz would have crystallised before the felspar and mica, and its crystals would have assumed a definite form amongst the other constituents."

We ask, in passing, what igneous fusion has to do with the subject? Mr. Mello is writing of quartz in relation to our chalk flints, sponge skeletons, the white lines in slate, &c., &c.; none of these have had anything to do with fire, neither is silica fused to enable it to clothe our grasses, or the hair of man's head.

Mr. Mello continues his examination. He found cavities in the granite quartz—some with air or water in them, some with crystals; and he thinks, from all his facts, "it is tolerably certain that the granite was formed under peculiar circumstances . . . never . . . as a purely molten rock . . . but melted partially, subjected to the action both of water and steam, charged with various mineral substances and subjected to enormous pressure."

Again, we stop to ask, why pressure is required to produce cavities, what proof is there of steam, what minerals were there, and by what action was the granite partially melted?

Mr. Mello cannot tell us "what the original condition of granite was; . . . its present condition shows it belongs undoubtedly to the igneous class of rocks. . . . Their origin was deep in the central portions of ancient volcanoes, where the various minerals came together and crystallised into granite." This sentence seems contradictory to what was said before, and directly opposed to facts gleaned from the sketch of a granite slice, magnified 26 diameters, given to us by Mr. Mello. In that sketch some of the crystals are worn and rounded, some with tolerably acute edges, indicating that they were not crystallised in their present position, as they must have been if they came together as Mr. Mello supposes. We now go on to M. Levy, quoting from the "Academy," 20th May 1876:—

"In relation to acid rocks, it is observed, that, under the microscope, they present the appearance of being composed of elements formed in succession at different epochs. The oldest crystalline elements are frequently broken and worn and rounded at their edges. They bear unmistakeable marks of the mechanical actions that accompanied their eruption."

As the rounding of edges could not be effected if erupted as soft matter, and as there are other methods of doing the same thing, we must have proof of eruption before we accept it as a fact.

M. Levy distinguishes the old crystals "from the more or less crystalline or amorphous magma by which they are surrounded, and which had its origin at the time of the consolidation of the eruptive rock. . . . In ancient granites the crystalline elements of the magma of consolidation have dimensions comparable with those of the ancient crystals, so that it is difficult to distinguish them with the naked eye. The ancient crystals are black mica, amphibole, oligoclase, orthose, and quartz, and the magma, orthose and quartz."

As the constituents of granite vary in every locality, it is remarkable how these two gentlemen coincide in their main facts. The magma of Levy is the matrix of Mello. We might dispute the applicability of these terms, but we gain our point without doing so. Levy says, "Recent quartz is moulded on earlier crystals;" Mello says, "The matrix must have been solidified after them."

Quartz is, therefore, the solidifying material, whether in a molten or in a cold liquid condition it percolated through and amongst the other crystal grains, and consolidated them into a mass of granite. This quartz melts at a higher temperature than the other constituents, yet they were erupted hard enough to be broken and rubbed, while the quartz is supposed by both to have been "moulded" and "solidified" upon them. When a similar geological education inculcates the same knowledge and the same conclusions, it is natural for the student to go no further. Granite is classed with igneous rocks, and these men have fitted their microscopic examinations of different specimens into their own groove. It does not appear that either of them consulted the beautiful unchanging laws of nature; if they had, it would have been impossible for them to accept their own interpretation of the facts presented to their eyes. There is nothing in those facts from which to assume eruptions, molten conditions, steam, or fire; while every fact reveals the certain action of cosmical elements under their certain laws. We are very much obliged to M. Levy and to the Rev. Magens Mello for the facts they have given to us.

We have now to fit these microscopical facts to the results of cosmical laws and elemental actions. For the sake of easy reference we will do this as the facts are laid before us.

Granitic quartz contains silica and oxygen, and is "the very silica" used in organic forms in precious stones, in petrifactions, in the white veins and masses of many rocks. In all these uses the silica must have been in a liquid or plastic condition previous to its consolidation. In the granite mass the mica and felspar are in definite crystals, while the quartz seems to have been penetrated by these when in a soft condition; consequently, the quartz "must have been solidified after" the other crystals.

In all the conditions alluded to, the silica and oxygen as one body was a cold matter, as it is when drawing up the blade of grass by the attraction of the sun, or when it oozes through the chalk and forms a line of flint. The formations we have mentioned above are naturally open and porous. When water oozes through those crystallised grains of silicious rocks, it brings with it silica and oxygen, and finds plastic silica in the mass. As the two join in affinity they form a cement to the other crystals, assuming such dimensions of crystallisation as the situation allows. According to M. Levy the older granites have their quartz more perfectly crystallised, thus supporting the general belief that quartz goes on increasing, and acting as a consolidating material; the older it is the longer it grows, and the more there is of it. Mr. Mello considers it "a remarkable fact" that the quartz should harden and crystallise after the felspar and mica. Under the laws of nature, where a cold plastic matter percolates through a previously-arranged mass, there is nothing remarkable in the action. Under the laws of Mr. Mello's imagination, the fact could not have existed. Mr. Mello has as much as told us this when he says the granite was not formed "in the ordinary way of igneous fusion."

Mr. Mello found cavities in the granite quartz. When a mixture of silica and oxygen percolates a mass of crystal grains, acting as a cement wherever it runs, there must be some cavities left unfilled, especially in new granites; as the quartz spreads around most of these cavities, the presence of crystals in them is unavoidable, while the air in other cavities is merely a proof that the quartz had not obtained sufficient force to expel it. All this is done without any melting, any steam, or any extraordinary pressure. Thus, again, the fact of a cavity in granite quartz is direct evidence of a cold formation.

Leaving the mental philosophy of Mr. Mello to find its own level, we must briefly look at facts produced by M. Levy.

Granite has "the appearance of being composed of elements formed in succession." This microscopic view tallies exactly with the law of nature. Whether the masses of mica, felspar, &c., &c., were of subærial or water deposit, they must have been gathered at different times, and they must have been more or less worn and rounded, as M. Levy found them.

M. Levy confirms Mello in the imperfect crystallisation of the quartz, as compared with the olden crystals.

M. Levy thinks the "magma" (quartz), by which his older crystals are surrounded, "had its origin at the time of the consolidation of the eruptive rock;" but he finds that in the older granites this quartz cannot easily be distinguished from the old crystals. If this quartz got into its position as a molten matter, it would have hardened at once in the different places it filled, but running through the deposit of grains, or crystals, with every accession of water, all the empty places became gradually filled, till the crystals of quartz, mica, and felspar were indistinguishable in the old granites. This fact proves the concretionary formation of granite, and tells us that as long as water percolates the mass, so long will it join with silica, making the rock more compact, and its crystallisation more perfect.

As far as the facts before us go, they fit most accurately to the elemental actions carried out by the laws of nature; each is a necessary result of cosmical work. We need not, however, expect a direct confirmation of these actions and their results in future microscopical examinations. No two places give the same material to work on; no two seasons give the same quantity of matter, the same forces for deposit, or the same amount of cementing quartz.

Material varies in colour, quality, quantity, constituents, and conditions. The character of the cementing silica may vary. Dry seasons give complete crystals; wet seasons allow a greater extension of its fluid condition, hence it runs into quartz lines, and masses, as it does in the graywacke of the Taunus mountains. This quartz infusion, the matrix, or magma, must, however, be present in all granite rocks.

We may now sum up our little history of granite formation. We are rather proud of our hard-hearted relation, because, in his varied formations, he is very capable of resisting elemental actions, and maintaining his cosmical position—this faculty was given in his construction. Our old ocean-bed, or fragments torn from it, supplied silicious crystals for the nucleus of the mass. Year after year material was added, either in stratified or unstratified forms, in the condition of the finest gneiss, syenite, or the coarsest granite. Subærial gravitation or water forces may have formed them all. Into these permeable masses of angular, broken, and rounded crystals water found its way, mixing, either before or as it passed through the mass, with such liquid or plastic silica as it met with, carrying it on as a liquid crystallising cement, apparently never ceasing till the rock assumed an impermeable condition, and, as M. Levy remarks, a complete sameness of perfect crystallisation.

We cannot say that the labour of forming granite was an arduous undertaking to dust. He came from a hard bed, he submitted himself to the care of the elements, and, in obedience to the laws, he formed a hard, a beautiful, and enduring fabric, bound together by the "nearly pure" silica, lent by the primeval rocks and by water. When man trusts to his imagination to interpret the natural objects before him, he often gets into error. He has for many years been trying to discover the origin of granite; failing to do so, he placed it to the credit of fire. We hope these microscopical examinations will relieve our relations of this accusation, and allow granite to be classed in future with water-formed rocks.

CHAPTER XIV.

SLATE.

Few of our rocks have been more knocked about in argument than slate; not so much in reference to its composition, as to the cause of its cleavage.

The extraordinary complexity of this natural split has been the puzzle. Man has not been able to ascertain why this cleavage is perpendicular in one place, at an angle in another, and horizontal in a third place. All these changes may be contiguous to one another, but each system may extend over wide areas, and every possible variety of cleavage lines may exist in this material, and all these changes may take place in rocks of similar composition.

We have seen under the head of "Mountains," what wonderful effects are assigned to slaty cleavage. We cannot help thinking that the present geological school has confused the subject by misunderstanding certain experiments, by which cleavage was shown to exist in certain earth masses, which had been subjected to great artificial pressure. The experimentalists and their followers quite forget that earth masses, by the manner of their deposits, must have a grain or fibre in them, and that this grain cannot be altered by any amount of natural or artificial pressure, any more than pressure can alter the lines of fibre in the gnarled root of an oak tree. If this point had not been overlooked, it must have been seen that the cleavage exhibited in the earths experimented on was due to the natural grain of the earth, and not to the pressure.

In saying this we are ready to allow that natural pressure has an effect on the cleavage of rocks. Thus cleavage is most perfect in old slate rocks, or in those masses farthest from the surface, upon which nature has exercised a vast pressure. Mr. Jukes remarks that cleavage, "where it exists, is always most perfect in fine-grained rocks, splitting them into an indefinite number of thin leaves or plates, perfectly smooth and parallel to each other." The finer the material the more susceptible is it of pressure. The only effect of pressure is to render cleavage more perfect by a closer cohesion of atoms, but it cannot cause the grain in a rock or alter it when it is there.

It is very remarkable how close science comes to the secret of cleavage without discovering it. Mr. G. H. Kinahan has lately repeated a saying by Dr. Haughton in reference to the force exercised by cleavage, accounting for it because "an obscure tendency to cleavage previously existed in the rocks" ("Saturday Review," 6th March 1875, and Hardwicke's "Science Gossip," May 1875). We shall see presently that there is nothing obscure in the tendency, the force depends entirely on the manner and quality of the cementing, but these practical scientific men did not discover the cause of cleavage.

Perhaps that careful inquirer, Dr. D. Lardner, in his "Natural Philosophy," p. 19, made the nearest approach to the natural system (there is something similar in Dana's "Mineralogy"): "Planes of cleavage indicate the forms of ultimate molecules. We must conclude, therefore, that the planes of cleavage are parallel to the sides of the constituent atoms of the crystals, and their directions, therefore, form so many conditions for determination of the shape of these atoms."

School-boys find occasional crystals in their slate-pencils, but, says Lardner, "these molecules are too minute to be the subject of direct observation." He continues at p. 20: "It appears reasonable to presume that all bodies whatever are composed of ultimate atoms having determinate shape and magnitude; that the different qualities with which we find different bodies endued, depend upon the shape and magnitude of these atoms." Just so, but Lardner had not watched the action of nature's forces; no shape or size of atoms could give the quality of cleavage, unless they were so placed as to cause a grain in the body. This grain is only given by the laws of force and gravitation. Atoms, when subsiding in water, become correlative to its force, and settle down in every line from horizontal to vertical, under their own power of gravitation in still water, or under the power of any force capable of acting on them in water that has motion. If Dr. Lardner had carried his subtle reasoning into slate cleavage, the subject would have long since been at rest.

In "Science Gossip" for May 1875, Mr. J. G. Halliday gives a useful practical illustration of cleavage in the muds of a Burmese river:—"I found the surface quite hard and dry; but the action of the sun, in evaporating the moisture, and thereby causing contraction, had caused a number of vertical or quasi-vertical fissures to open up, of very considerable depth, extending, indeed, so far as I could ascertain, quite down to the bottom of the bed of recent silt."

These river mud beds are deposited on the confines of floods, when the subsiding water allows the lighter suspended matter to settle. All this matter forms a fibre in the act of settling, and the fissures are the evidence of the line of fibre. The finer the material the finer or smoother is the fracture.

Jukes was aware of this; he also knew of the fine gradations of material when he said (p. 147), "shale and slate indistinguishable." The "Challenger" discovered at great depths in the ocean similar gradations now in progress.

These gradual mergings of one formation into another ought to have taught our geologists more about water action, while the varied condition of different materials in the earth in vertical descent might have shown them how materials and forces changed in the same spots at different periods. In consequence of a want of observation, or, perhaps, of a peculiar schooling, unknown forces were evoked to produce formations due to the ordinary elemental actions, under their own immutable laws.

Sir Charles Lyell ("Principles," 11th edition, 1870, p. 300) tells us that, "The subterranean forces visited different parts of the globe at successive periods, is inferred chiefly from the unconformability of strata belonging to groups of different ages. Thus, on the borders of Wales and Shropshire we find the slaty beds of the ancient silurian system inclined and vertical, while the beds of the overlying carboniferous shales and sandstone are horizontal."

It is difficult to see why unknown subterranean forces were called into account for ordinary results of certain laws. The old slate beds referred to subsided as mud in quiet water, resting on the uneven ocean bed. This mud, forming a cast on its mould, followed all the undulations, and left its formation inclined or horizontal accordingly. These formations are liable to change their surface conditions by contraction under pressure and drying. The carboniferous shales and sandstones were left on the first deposits by currents; they consequently filled up the hollow places and assumed an horizontal surface. The unconformable condition was, therefore, unavoidable under the laws of deposit. A change of water force at varied depths, and a consequent change in the deposit of matter, is a very common event. There is no deposited rock that we know of so dependent on fickle cosmical changes as slate. The history is too long and too complicated to write in full, but we hope the subject will be comprehended from a simple outline of a few cosmical actions, by which fine deposits of all sorts are acted on at the time of being deposited.

We have shown in Chapter I., and elsewhere, that the sun rules the atmosphere and the waters. In the temperate zone we daily experience its fickleness. We find samples in the meteorological reports. We quote a sample that comes to us while writing: "The changes in atmospheric pressure over Western Europe are still very complicated. The depression which lay off the north-west of Scotland yesterday has travelled away to the northward, while the secondary disturbance which was over Wales has moved eastward. . . . The weather is, consequently, in a very unsettled condition over our islands." These changes are not things of to-day, they are the necessary result of our cosmical position, and have been going on long before the first dry land of the British isles appeared above the waters.

Slate is plentiful in these regions, and these atmospheric changes acted on the waters during the deposit of the suspended atoms, by which our slate masses are formed. It is impossible to follow upon paper the extreme minuteness of changes in solid rocks, which were caused by the variations in the forces, and by the variations in the material at the time of deposit. The material may have been in suspension, or solution if in the water; it may have been as dust or vapour if in the air. Wherever matter is, in whatever condition it may be, it is used somewhere, either as a deposit, or, by the laws of absorption. We may touch briefly on this curious and interesting system, it will lead us to comprehend something of the delicate manipulation in slate formations.

We have already alluded to the gradual merging of one formation into another by water action. Water holds metals and minerals in suspension and solution; their colours are exhibited by the flora and fauna of that element; they are also shown in water spray, in the rainbow, and in the vapour cloud. Dr. Hennesey in his report, No. 5, on the atmospheric lines of the solar spectrum, gives his reasons "for ascribing the differences in certain parts of the solar spectrum, sun high and sun-set in all cases to the influence of the earth's atmosphere," and he found "a visible connection between the atmospheric lines and the terrestrial atmosphere." These lines are marked by colour in a vapour condition; they all merge into each other by slow or quick gradations. The fauna and flora of the earth accept more or less of these atmospheric colours in a quick or slow gradation. In whatever manner these colours reach the positions in which we find them, they must have been as vapours or as solutions.

If we look upon the earth's surface, or below it, we find all the colours of the atmosphere or water retained in the hard or soft stratifications: in all places they are more or less graduated. These colours may have been deposited millions of years ago, but they are the same as those now depositing on the deep ocean-bed. Man has not written the history of these subtle-coloured vapours and solutions; there is in it a long and beautiful tale of varied weights and characters; of metallic pulverisations and mineral triturations; tales of aerial travels and water voyages; with curious anecdotes of evaporation, absorption, and percolation.

These beautiful manipulations, the charming gradations, are all done under the law; every colour is correlative to the force that places it where we find it.

It may have fallen to the lot of some to watch a crystal river pool under the first influence of a flood. A wave of muddy water intrudes upon the border of the pool; every now and then a surging pulsation from the swelling stream increases, and pushes on the thickening water. Surge after surge rolls on; the crystal space has grown smaller and smaller, till a thicker wave comes on and loads the pool with thick suspended matter, and the finer solutions, all urged hither and thither as influenced by the changing movements of the flood.

The action in the pool is analogous to the action in the atmosphere; the colours and the solutions are correlative to the forces that placed them in their respective places. The dust that dances in the sunbeam within our rooms is another similar action; dust, solutions, and colours are all left somewhere in their respective graduating conditions.

The materials which made the colourless slate were liable to similar actions; they were all correlative to the changing forces around them. A water-current, laden with the slate materials, will first deposit its coarser material, because it is the heaviest; as the current gets weaker, the finer materials subside; both of these may be left in horizontal positions, but each graduating into one another with an imperceptible junction. The lighter material goes on in the still weaker current, gently graduating in its deposit till the formation is left with some angular, and lastly, as the current force dies away, some with a vertical fibre;—the line of cleavage or splitting, in all cases, following the lines of fibre or grain.

As there are masses of clouds, and of colour without graduation, so there are abrupt knots of slate without any determined grain; it runs in varied slants, in curves and lines, just as the wind blows from all points of the heavens. These exceptions help to prove the rule. Wind and water have their eddies, their gusts, and their whirls of varied power. The last touch of the fickle elements determines the line of grain in the deposit.

We may then accept all the changes in slate cleavage as direct proofs of change in the quality of the material, or in the force of the depositing water. In the process of drying and contracting, changes in the position of masses may take place, and the pressure of overlying strata may cause a more compact condition; but no pressure and no contraction can in any way alter the direction of the grain as given in the formation of the mass. We have a familiar analogy to these unalterable formations in our corn-fields: a strong wind or heavy rain lays the upright corn flat upon the ground in one uniform lay; whirls and eddies may lay the corn in all possible directions. Man cannot alter these conditions; the reaper finds the complexity of the corn-field as the quarryman finds the complexity of the rock.

We have before us a subject complex from the very nature of the forces of the for ever fickle winds and waves. When we can count their changes, we may better comprehend the perfection of the laws for slate formation. To this formation we dusts look for the evidence of the force which left it. We do not stop to ask why one rock cleaves vertically, and another at an angle. We know that these results are the evidence of our own obedience to the laws of force and gravity. With a uniformity of both, we find uniformity of sediment. With variation in both, there must be variation in sediment.

Under these conditions we find in every slate rock certain proof of the correlation of its constituent parts to the forces at the moment of deposit; and another proof that, under the most complex conditions and actions of cosmical laws, we dusts have still attended to the doctrine, "Forsake ye not my law."

CHAPTER XV.

THE FLAGSTONE.

THE last rock on which we shall touch is that useful and familiar slab which forms the footpaths of London.

Our stick-supported footsteps linger on a flagstone in front of the home of our youth. The slab has an undulating surface. There are three projections on it of a bluish colour; a reddish line streaked with white runs along one side, and several irregular hollows spread over the surface. We measure one of these; it is 1½ inch deep, with gradually sloping sides, showing twenty laminæ, or sheets, like the edges of rough brown paper overlapping one another. This flagstone, of some two feet square, has its mountain range, its hard tors, its little lakes, its miniature seas, and its microscopic rivers; each filled by a drop of water, or a shower, and each dried up in a minute, or an hour of sunshine; its present condition due to human footsteps, aided by the elements; an epitome of our great world as worn into its present state by the ever busy footsteps of nature.

We pick up a fragment from one of the laminæ, and carry it home; it is rubbed into a brown-coloured gritty paste, and placed in a tumbler, water is poured in till the whole is in solution or suspension, when it is left at rest on a shelf in a warm room. On examining the treasure next day with a magnifying glass, the water is found clear, a light dust on the surface, some strange-looking creatures swimming about, busy with natural instincts, including that of eating up one another, and reposing on the grey, gritty, tenacious sediment, with minute sparkling matter here and there in the bottom of the tumbler.

It was once said by a wise man, Josephus, that "nothing does so much cement the minds of men together as the alliance there is between their manners." Thus, no earthly materials do so firmly cement together as those which have an alliance in their constitutions: what is there in the matter in our glass which has settled down so firm and smooth? We shall find this out from two analyses, which are borrowed from authorities.

	Limestone.	Sandstone Flag.
Silica	1·20	98·3
Carbonate of lime . . .	95·16	1·1
Carbonate of magnesia . .	1·20	0·0
Water	1·94	0·0
Iron aluminium . . .	0·50	0·6

These may be considered extreme constitutions; silica abounds in one, lime in the other, and all that we walk upon in these streets contain more or less of the matter here given. The definition of a flagstone, as given in Ure's Dictionary, is "a stone which splits freely in a particular direction along the original lines of deposition of the rock. These are generally sandstones, and the splitting surfaces are frequently produced by a thin laminæ of mica; but thin bedded limestones also furnish flagstones, of which some beds of Purbeck limestone and the Stonefield slates are examples. Flagstones are also obtained from lias limestones, which are, in fact, thin beds of indurated clay." With these facts before us we stand on the brink of a vast field of scientific inquiry. It is not our purpose to step into the labyrinth, but the little we shall say, in passing by it, will convince some, that, if we did, we should never get our feet out again; whilst it will suffice to show how minutely our geologists go into the subject. Dr. C. W. Gümbel writes, in the "Transactions of the Bavarian Academy of Sciences," 1871 and 1872, "on the so-called Nullipores and their participation in the composition of calcareous rocks." T. R. J., in noticing this subject in the "Geological Magazine" (No. 105), says—"The difficulty of working out the characters of these Gyroporellæ imbedded in hard limestones has been very great. Dr. Gümbel himself looks forward to still more complete results being obtained from continued research. Evidently these organisms are to be looked for in other jurassic and cretaceous strata besides the Neocomian limestone of the Wetterstein; the Verticellipora anastomosans, and its varieties, in the Farringdon beds, would repay the labour of careful examination by a dactyloporist. The great difference between the triassic forms, Gyroporellæ, without true chambers, and the tertiary Haploporellæ and Dactyloporellæ with true chambers, is very striking. But certain tertiary forms—Thyrsoporellæ—approximate to the Gyroporellæ, and if the last be simple in some respects as to structure, nothing can be simpler in make than several of the latest Haploporellæ, mere rings or half-rings of adherent sacks. That these little creatures have mightily aided in the construction of all limestones is of great interest to the geologist." "We are (says Jukes) almost compelled, therefore, to conclude with Bischof that all our marine limestones have been formed by the intervention of the powers of organic life, separating the little particles of carbonate of lime from the water, and solidifying them in order to form part of a solid rock." He tells us elsewhere that there are rocks entirely made of silicious substances from microscopic animalculæ.

We can add to this that the whole surface of this earth is nothing more than decomposed, and altered, and mixed organic matter. Millions of organisms have been counted in a cubic inch of rock, and in an ounce of sand; a microscopic drop of water contains living creatures performing all the functions of nature, and we once saw seven dragon-like creatures eating up one another in a minute drop of paste. This prevalence of life is so well known in the East that a certain class of Brahmins cover up their mouths with a cloth, to prevent their swallowing life with their breath. The reader will understand from this, that from the first grass, the first herb and the first tree, from the link between vegetation and animal, the minute diatom, or other microscopical organisms, to the great Saurian, and the vast Mastodon, from the Gyroporellæ to the enormous whale, from the beginning of creation down to the present moment, no creature has ever lived, no plant has ever grown, without contributing, in life and in death, some material to the dust of the earth; something for the wind to blow away, something for the water to carry off, something to add to the structure of this dry land.

This brown tenacious matter, dotted with spangles here and there, which yesterday formed part of a London foot pavement, and now reposes in the bottom of the glass, is then derived from water and atmospheric gases; vegetation inhaled the latter with its leaf, and drew up the water with its root. By a process of mechanical and chemical arrangement, brought about by warmth, on which we do not enter, this water from the earth, and the gas from the air, were converted, as they are at present, into organic forms fit for food; in this state they maintained animal life, so that the matter before us is composed of the organisms of earth, air, and water. How were these materials converted into the condition in which we find them?

We must go to the sea-side for an answer to this question. That which we find done by universal laws at present must have been done since creation began. We need not expect to find any deposit of to-day identical in composition with that which was deposited by water in unrecorded time; we all know that the earth is perpetually producing new things, that the fashions of creation change, but not so frequently as they do in our streets. Sir Charles Lyell has told us: "That, in the course of ages, one assemblage of animals and plants had disappeared after another, again and again." He also tells us "that calcareous matter of shells is often entirely removed, and replaced by carbonate of iron, pyrites, silex, or some other ingredient," so that the reign of fashion extends to the inanimate world.

Under the dominion of Nature, material produced in one place is found by us in another; she uses the whirlwind, the cyclone, and the tornado, for the removal and deposit of some things; while others are carried by rivers, ocean currents, and their whirlpools. All through their removal, matter is selected from each, the heaviest drops by the way, the lightest goes on as long as the carrying agent has strength to carry it. Clouds of ashes have been wafted over the Atlantic; Ehrenberg fell in with a shower of silicious skeletons; sea-fish have fallen with rain, far in the interior of great continents. Dead and dying fish have been sailed through for a distance of 50 miles, supposed to have been driven from their usual haunts by ocean currents. Lyell tells of a swarm of medusæ, 45 miles wide, feeding on silicious diatoms, 700,000 to each, while whales were feasting on the medusæ.

All this change is going on now; every one will comprehend that it must have been going on from the beginning; but it was reserved for Palmieri, the brave Italian Professor, who endured the heat of Vesuvius almost to roasting point, to show that the eruptions of 1871–72 gave direct evidence of the fact: he found the lava of 1871 "rich in leucite and containing little or no pyroxene," while that of 1872 was "poor in leucite and rich in pyroxene." There are many who imagine that these outpourings of lava come from one great source, or from basins always full of molten rock. If such were the case their surface outpourings would necessarily be more homogeneous; but if, as we have so often shown, local causes produce the heat, then that heat, acting on the rocks adjacent to it, must necessarily expel such varieties of lava as those differently constituted rocks would supply. The fact may be accepted as proof that the lava is formed from rocks of deposit, exactly as slag is formed from varied rocks in the furnace; and that these rocks of deposit were formed from different materials, and by different currents, as deposits are formed at present. We see deposits stretching for hundreds of miles, of one character, to great heights; we know that water placed them where we see them; and we know that these deposits were left, as they are now, as great solid masses, as rough shingle, as gravel, sand, and broken shells, as soft mud, or firmer lime, and silicious composition. As long as the force of the current retains its power, as long as the same material is found by that current, so long will the deposit be of a similar nature; but the more the productions of the earth and water vary, so change in deposit will be more frequent. Before we can answer our question, how these materials were brought into their present condition, we must watch the action of the water; in doing so, the words in Lamentations iii. come naturally to our pen,—"He hath broken my teeth with gravel stones." The wave breaks and hurls all the material held within it on the shore, the mighty rush of waters sends the gravel and the sand rolling as far as the force can carry them; the retiring wave forces some back again, to be put again into the mill; so that the grinding and trituration is done over and over again; the boulder is worn to a pebble, the pebble to sand, all argillaceous matter is kept suspended in the water for a time, the clean silicious sharp sand is left in one place and the shingle in another.

If we move our position from the open sea-beach to a more retired spot, sheltered by a projecting headland, we find another condition of deposit. The gentle ripple has left at high-water mark a waving line of light material. Below this line of varied *debris,* we find that each ripple leaves something behind it, while over it we find, in smooth spots, a glazy scum, a light silicious matter, similar to the inside of the silicious pellicles that are formed from the wind-rolled scum on the flat sands of the Beemah River in India, a few of which stones have been floating in water for several years in the beautifully-arranged Geological Museum of Jermyn Street. Under the action of drainage and pressure this scum deposit has assumed the character of mica, and defines the line of splitting in some of our flagstones.

As the tide retires, a little watershed from a gentle slope trickles through the new deposit, and cuts its channel through some two inches of sedimental matter. The sides of this cutting are nearly vertical, exhibiting the thin deposits of many tides. There is a tendency in these sides to wash away; the untenacious matter is carried off, while the thin filmy scum holds together, and protects the particles nearest to it, so that down the whole face of the small channel the layers can be distinctly traced. As the little river runs along it meets obstacles, and turns aside. If we examine some of these, we find them composed of argillaceous silt, with occasional silicious or iron concretions. They withstand the footsteps of nature in the passing stream, as they withstood the footsteps of man in the blue nodules of the foot pavement.

We must pause a moment in our history to consider these concretions: here and there over the plains of England, and other countries, we fall in with large masses of hard rock, unlike any neighbouring mass, sometimes gathered together by man, as at Stonehenge, in Wiltshire; or looking at our calcareous and our sandstone quarries, we find similar large masses. In our landslips and in the sea-side subsidences, these concretions are found again. Similar silicious masses were found in boring tunnels through the Indian mountains; so that it seems as if all sedimentary deposits contain in them more or less of mineral or metallic matter, which, percolating through the mass, accumulates on some nucleus, or forms one for itself, till the percolation ceasing, leaves an indurated boulder of a size equal to the extent of rock into which the cementing matter has infiltrated, but very different in character to what it was, or to that which surrounds it.

We will now leave the water-side, and look at the limestone cliff; a thin streaked line of quartzose matter runs across a projecting pillar. These lines can be found in most rocks. We suppose them to be the infiltration of silicious and calcareous matter, which forms into lines in their respective tenements, exactly as silicious matter forms into lines in chalk formations. As there is no formation without the remains of life, and as silex accompanies all life, as it is a percolating, and a cementing, and a crystallising material, it percolates through the new soft chalk, till it meets with a firmer layer, through which it cannot pass. The silicious matter rests on this layer; it adheres to, and naturally gathers round, any nucleus found on this layer; it forms into nodules of itself. The nodules thus made often conform to the flatness of the hard layer, while the upper sides form into such shapes as the situation allows, or as the growth of their own bodies demands. As the new chalk layer is soft and compressible, these silicious nodules, our chalk flints, assume all manner of shapes, while other rocks (silex and its mixtures), by their firmness and consistency, confine the percolating matter in straight lines or in larger masses called quartz.

In thus showing how deposits are made to-day, how materials are changed from what they were by mechanical and chemical causes, we answer the question, How were these materials converted into the condition in which we find them? We have found analogies for our white-streaked quartzose ridge, for the blue silicious nodules, and for the general formation of our flagstones. They are making now, they have been made ever since calcareous and silicious matters were acted on by water-currents. These waters have been at work from the beginning; the results of their labours are before us. Long before dry land appeared, or any vegetation grew, they heaped up the void primeval matter into firm banks and hard ridges; they added atom to atom from their own bottom, they naturally subsided a drop for every atom worked up beyond the surface; so that, as they raised those early banks, the remains of which we see in the *Pamir* steppe—"the roof of the world"—in the Himalayas, the Rocky Mountains, and the Andes; the waters were at the same time making their beds deeper all over their vast area. Thus, without any diminution of the volume of water, it has necessarily retired from the dry land, leaving its vast records to tell of its former surface level and its smaller depth.

Can man see the time required for these arrangements? Science is in a dilemma on this point. Sir W. Thomson gives 10,000,000,* Sir C. Lyell and others give 300 or 500 million of years, as the duration of life on this earth, on which Professor Tait remarks in his Lectures, 1876, "So much the worse for geology, as at present understood by its chief authorities." We beg to amend this dogma, and say, So much the worse for the authorities. Can man measure the quantity of dry land, or weigh the volume of water round it? It was long imagined that the sea-bottom was calm and motionless. With heat to expand and cold to contract, with evaporation drawing from it, and rain falling on it, with rivers running into it, and storms blowing over it, with its own currents always moving on the surface, and below it, a calm bottom was impossible. Her

* 50 or 100 million—"Age of this Earth."—Geographical Magazine, February 1877.

Britannic Majesty's surveying ship the "Challenger" has just discovered the fact. The *Times* of 1st of April 1873, gives the following notice of her discovery: "The nature of the bottom brought up, and the way the trawl and dredge frequently catch in being dragged along, prove, undoubtedly, that the bottom of the sea, even at great depths, is not so smooth and free from rocks as has hitherto been supposed. A conclusion drawn from this fact is that a considerable movement of the water at the bottom must be going on." How any one could doubt this will now be the fashionable question. The "Challenger" has also confirmed late discoveries, that the ocean bottom is full of life; little creatures filling up the measure of their existence in cold and almost darkness, but all sharing in the harmony that reigns over this globe, each kind gliding with an imperceptible step into the character of its neighbour, all depending on the genial sun; and combining sooner or later with the vegetation of sea and land, with insects and crawling things, with birds of the air and with beasts of the field, to replenish the earth that produced them.

Nature, with her never-changing laws, does all this. She has obeyed the command of the Creator; she has increased and multiplied, subtracted and divided; she has circulated and deposited in her savings-banks all materials left to her charge: she has sent tropical produce to the Arctic and Antarctic regions; she has scattered the dust of one hemisphere over the other in the smallest possible molecules; she walks on the winds of heaven and the waves of the sea, her footsteps never rest from the labour of recreation and redestruction; all things are subservient to her forces, all unwittingly contribute to her service. Thus, together, they have built up the dry land, and in every habitable part of that mankind is found. What is he doing to assist nature in the circulation of matter, or in preparing foot pavements for the coming race?

Man is supposed to be an improvement on other animals. He may expect that future races will go on improving. He dates back into mythical times—his successors may be equally distant. He cannot arrange his preparations for them, but there is a good deal going on amongst the present human beings on the world's surface; their footsteps are very active, their footpaths are well worn, nearly as well as the London flagstones. There are many undulations on the way. Does he comprehend the reciprocities of nature, the circulation of matter, the nature of the elements, their obedience to the law, visible and tangible to himself in the light and heat of the sun?

Let him answer these questions as he will, taking the analogy of himself. London occupies an irregular space, containing, by the census of 1871, an area of 441,587 acres. There are 528,749 houses inhabited, and at this moment there are living in them about four millions of human beings. Every one of these, from the sovereign downwards, is more or less dependent on his fellow-creatures. Our wants multiply as population and wealth increase. The materials to supply these wants neither grow nor live within the area of London, and yet there is no place in the world that can so readily satisfy our demands. From the jewels in the crown of our sovereign, down to the nails in the shoes of the labouring man, everything that we wear or use in our houses, is imported from other places; our iron comes from the bowels of the earth, contiguous to our flagstones; metal comes from the same place, all round the world; we get our cotton garments from America and India; our silks from Europe and Asia; our linen from Russia and Ireland; our wool from Australia and New Zealand; our beautiful woods and dyes come from any region that produces them. London has her sons and her merchants in every port, and in all lands; the sun never sets on the empire of our Queen, and every man, in every portion of it, is occupied in administering the laws, in teaching religion, in defending our Penates, or in ministering to the wants or demands of others. Man, like nature, uses the wind and the wave; the routine of nature was not fast enough for him; he treasures up the water, and expands it into steam; he treasures up the storm to produce a greater force, and with these appliances he sends his floating palaces all round the world upon the well-known pathways. Our ships are our great circulating machines; they bring the raw material to us, and take it back as a manufactured fabric to those who grew it. These ships bring us the vegetations of the East for our beverage; they take salmon from Scotland to Hong Kong; they bring back the edible bird's nest from thence; meat from Australia; turtle from the West Indies; whale oil from the frigid zones; in short, the whole known sphere is more or less occupied in supplying the wants of this great city, which, in its turn, pays for the occupations, and circulates productions, reciprocating the labour of the producer and reaping the harvest prepared by the law. Will man allow the same reciprocity to nature?

He was a brave man who first launched his frail canoe on the heaving wave, and brave men are occupied on it at present; the dangers are as frequent as ever, and as the size of our ships increases, so more go down, and

> "Sailors and women silently come
> Through the winding waters now and then,
> And the great sea murmurs—'Amen! Amen!'
> In the pauses of its song."—B. M.

There are two lists of lost ships before us, one of five, which, in a time of peace, went to the bottom with 2215 persons; the other, of the same number of fighting ships, which went down with 4150. The "Hour," 2d July 1875, gives, on the authority of Mr. Plimsoll, a loss of 56 ships of 24,816 tons and 683 men. History counts its dead men by the million on the battle-field; there, and in the water, the bodies give back their gases to the air; their dust to the dust, and their liquids to the water, each element mixing with its own, cementing with that to which it has an alliance, and scattering the rest where the winds or the waters please to take them.

There is a future for all this, and for all man leaves behind him, his cemeteries will hide some of his remains, till the never-resting footsteps of nature-subtracting converts the small remnants to dust or to mud; while millions of years hence coming races will find, accidentally, the cave bones of human beings, as he finds the cave bones of animals, and the cave collections of vegetation at present. The great ships in which the crews and the passengers are now swallowed up by the relentless waves, will some of them be covered over with lime solutions; they will form grander mausoleums than would have been found at the hand of man. There will be no epitaph, no name on the great sarcophagi; but the wise beings of races to come will comprehend the subject, when its record is lost.

"So out in the night on the wide, wild sea,
When the wind was beating drearily,
And the waters were moaning wearily,
I met with Him, who had died for me."—B. M.

A weird meeting-place; but one as much cared for as the heights of Pamir, or the Paradise of Adam. It is the place in which Nature is storing men up with a lavish hand for future use, as she stored up long ago the silicious and calcareous dusts as flagstones left on the stream of time for him; a place in which men are deposited in great masses, as bones of animals and remnants of trees were left in unrecorded time. It is the place on which the Creator prepared the soil by a long long process for the use of man, to produce oil and wine to give him a cheerful countenance; a place on which he has hoarded up so many things useful to mankind. Is man grateful for this forethought, or does he take from all these hoards as his natural right, without a feeling of thankfulness and gratitude? If we thought in our youthful days, we fear the flag-stones of our pavements had as little of our gratitude as the shoes on our feet. It is not so now, but as we look on these slabs we recognise the growth and the life of forgotten time, the lengthened shadows of an eternity; we see the footsteps of nature slowly but surely creeping on, rejoicing in the sun-light, growing in the rain, exulting as she walked along with smiles and songs of praise, partaking of all that spread its ample feast before her, lighting the torch of love, in-creasing, multiplying, and dying. Subtracting, divid-ing, reconstructing, reproducing through the agency of our ancestor Dust.

Reader, have we kept our clue in hand through the brief windings of our cosmical labyrinth? Have we traced a few actions of Dust to their source? Have we explained the present from the past, the past from the present? Have we shown how, at all times, in all seasons, Dust has been obedient to the laws? Have we traced these laws to a visible fountain-head, to the source of light and heat, of energy and lassitude, of life and growth, of the dust, the air, the water, and all the organic formations dependent on them? To us Dusts that source is the sun. We feel our obligations to this heavenly light. Our great ancestor felt the same influence. There has been no other light, heat, or cause of life from his time till now; there has been no other law to which we owe obedience. With nothing to distract us, with no temptation to decoy us, we have passed so far through the even tenor of our existence.

We are fain to acknowledge that, beyond our visible lawgiver, there must be an omniscience that codifies the law. Into that Almighty presence we Dusts cannot intrude with our poor physical gifts. We are content to know, that without this power we could not use them, but that, with that aid, we may employ them for good. Happy in the obedience to law, content with the result; grateful for the past, hopeful for the future.

CHAPTER XVI.

Epilogue.

A SEANCE—MEDIUM—SPIRIT OF SOCRATES—DUST.

Dust.—We have been in and about your room, O Medium, for a long time, without hearing a word of science, or feeling the spirit of any old and true philosopher.

Medium.—You might stay here for ever in the same want. Philosophy is not in fashion, and our occupation is low.

Dust.—Raise it by calling old spirits up.

Medium.—Whose?

Dust (*in a whisper*).—Socrates'.

Spirit.—I hear, make haste, it is cold!

Medium.—From whence come you, O Socrates?

Spirit.—Eternal sunshine!

Dust (*in whisper*).—What is science?

Spirit.—Speak lower next time; your breath annoys me! I have just had a joke with the ghost of Theætetus on that subject. I told him the old tale—"A river shows its own depth!" Science has become shallow; men bathe in it, as they are instructed by their masters.

Dust.—Is that science?

Spirit.—Yes! if it meets the occasion.

(*Something like a laugh is heard.*)

Dust.—We have heard, O Spirit, "that true judgment, in conjunction with reason, is science; but that without reason it is out of the pale of science; and that things, for which a reason cannot be given, cannot be known." Tell me, O Socrates, if science has formed a true judgment, with reason, on the elements of earth?

Spirit.—I am not at liberty to tell of knowledge gained in the spirit-world, but as you seem to have forgotten it, I will repeat a word said long ago to Theætetus:—"Some people say that the first elements, as it were, from which you and all other things are composed, cannot be explained by reason, for that each several element by itself can only be named, but that nothing else can be predicated of it—neither that it exists nor does not exist; for that this would attribute to it existence or non-existence, whereas nothing ought to be added to it if one means to speak of the thing itself only; neither must we add to it the term the, or that, or each, or only, or this, or many others of the same sort; for these are constantly varying, and are applied to all things, and are different from the things to which they are added. But we ought, if it were possible, to speak of the thing itself, and if it has a definition peculiar to itself, to speak of it without the addition of anything else. Now, however, it is impossible for any of the first elements to be explained by a definition, for it does not admit of anything else than being named, for it has only a name. But the things that have been composed from these as they are complex, so their names, when connected together, constitute a definition, for a connection of names is the essence of definition. Thus, the elements cannot be defined or known, but only perceived; but things compounded of them can be both known and defined, and apprehended by true judgment. When, therefore, any one forms a true judgment of anything without explanation, his soul, indeed, perceives the truth respecting it, but does not know it, for he who is not able to give and receive an explanation of a thing must be ignorant of that thing, but when he adds an explanation to it, then he is capable of knowing all these things, and may be perfect in science."

Dust.—Science, then, is a definition with true judgment; therefore the elements of this earth cannot be true, because they cannot be defined.

Spirit.—" Science is correct judgment with the science of difference. . . . Neither perception, nor true judgment, nor logos united with true judgment, can be science."

Dust.—Tell me, O sapient spirit, what is fire?

Spirit.—The sun!

Dust.—The fire of interior earth?

Medium.—The spirit is gone; he told you a secret of the spirit world. I recollect the end of his discourse with Theætetus. It is one of my mottoes, but may be extended—"All these things are empty, and not worth rearing."

Dust.—No wonder science and philosophy are out of fashion, when no one knows what science is, and the spirit of Socrates cannot define elemental matter. We are complex, our compounds are more complex; no one comprehends an elemental trinity, or the cosmical laws by which that trinity is ruled as a whole, and in its individuality.

We have endeavoured to follow the law, as affecting a few incidents in the long and busy career of our ubiquitous family. We do not call a careful and a truthful following of the law a science, although each incident may be defined by correct judgment. As long as we follow the law of this universe, we cannot be without truth.

We have shown the origin of dust, and the origin of organic structures. We have indicated the ostensible lawgiver, and pointed out the obedience of the elements to the law. We have shown a reason, and a meaning, for the beginning, with a continuation of the end. We have used plain language for the incidents and the arguments connected with the biography of our family. We are small individually, large in the aggregate. We are atoms in that vast system of organic structures now adding their mites to our formation, and we are atoms in that formation which had its beginning from dust, is dust still, and will be dust as long as the sun rules this universe with its almighty code of laws.

Medium.—Will any one bathe in your river?

Dust.—It is only a little stream, and very safe. Those who can see under water may find some beauty in the pure foundation.

[*Exeunt.*

NOTE.—These quotations are from Cary's translation of "The Works of Plato," "Theætetus, or, On Science," 1848.

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