THE WONDERS OF NATURE

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NATURE.

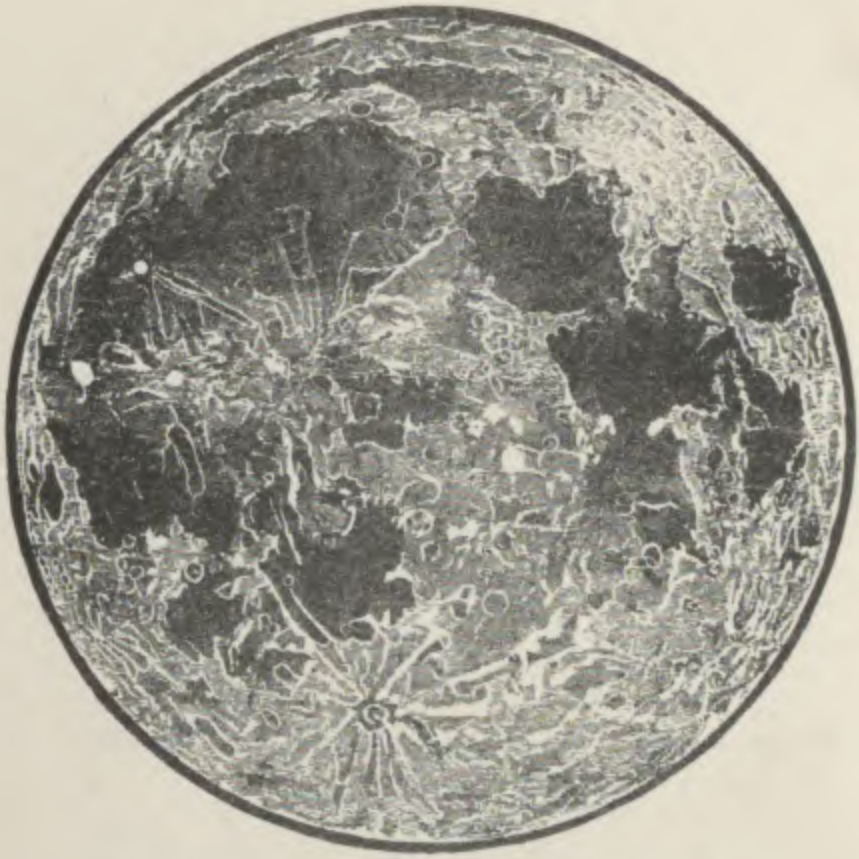
BY

PROFESSOR RUDOLPH.

Reprinted from the Fife Herald, Fife News, and St Andrews Citizen.

EDINBURGH: MENZIES & Co.
CUPAR: "FIFE HERALD" OFFICE.

PRINTED IN THE "FIFE HERALD" OFFICE, CUPAR.



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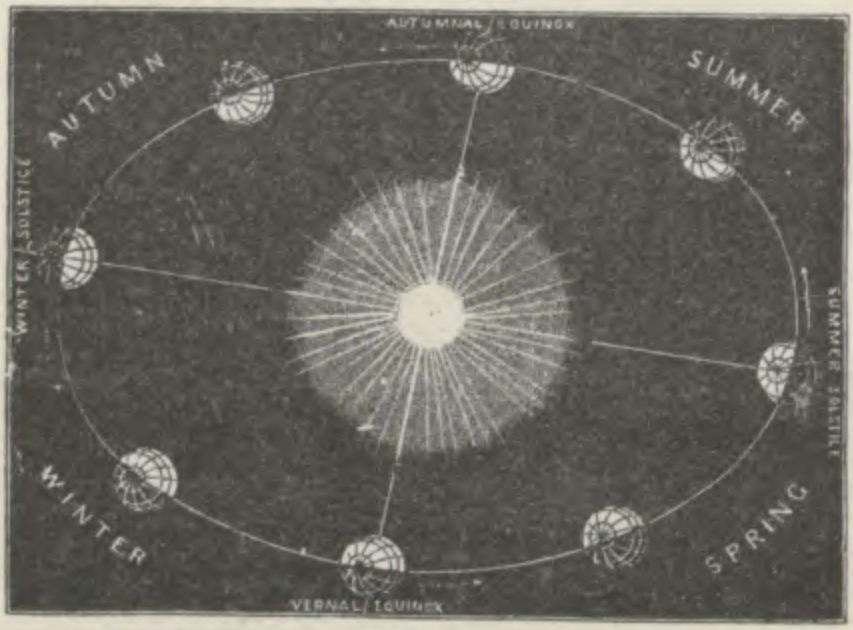

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PREFACE.

The publication of this little work is the result of an after thought. While the articles on the "Wonders of Nature" were appearing from week to week in the *Fife Herald*, *Fife News*, and *St Andrews Citizen*, numerous readers expressed a wish that they should he printed in a form in which they could he preserved and conveniently referred to. We have complied with that wish, and added one or two astronomical views, which could not well he produced in the columns of an ordinary weekly newspaper. To those who have already perused the articles of which this little volume is comprised we need not say anything in commendation of them. In this form they will, we hope, find numerous new readers, whose minds will he instructed and enlarged by the many stupendous facts in Nature which they so clearly and intelligibly expound.

THE PUBLISHER.

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THE WONDERS OF NATURE.

WHAT IS THE SUN?

No question, probably, has been so often asked by the civilised man and the savage. Its overpowering splendour, its welcome light and genial heat, its evident influence upon animal and vegetable life must have made it an object of greatest interest in all ages. Adam, doubtless, looked wonderingly and with awe upon it from the bowers of Eden, and like all his children must have regarded it as the most mysterious and stupendous of the creations of God. The Parsees or fire-worshippers of Persia, worshipped it as God himself.

We, of the present day, are more favoured than the old Patriarchs, and the school-boy of this age is better acquainted with this wondrous body than were the hoary sages of antiquity.

But there are some yet needing instruction. We will endeavour so to write that they can understand.

What, then, is the Sun? Modern science declares it to be a vast globe of matter, either *melted* by intense heat or white hot. This fiery globe is surrounded by an ocean of gas, and this gas is on fire. This ocean of fire, enveloping the heated solid body or liquid mass of the Sun, is estimated to be about fifty thousand miles deep. The diameter of the Sun itself is about 856,000 miles. It is difficult to conceive of a body so large as the Sun. It will help us somewhat if we suppose our globe to be placed at the centre of the Sun, and our Moon then placed at the same distance from the Earth that she now is—240,000 miles; and the Moon would not only have room enough to revolve around the earth, inside the Sun, as she now does, but about one hundred and eighty-five thousand miles over; that is, so much room to spare. Now add to this great white hot globe an ocean of gas on fire, fifty thousand miles deep on every side, and that gives you a diameter of almost one million of miles. We had a most striking proof of the existence of this ocean of gas on fire at the last total eclipse of the Sun, seen August 7, 1868. At that time, when the Sun was totally obscured, there appeared five or six immense tongues of flame from this great ocean of gas on fire, and these tongues of flame shot out in different directions outside the dark body of the Moon, and were estimated to be about fifty thousand miles in length! Think of a tongue of fire fifty thousand miles long! What a mighty ocean of raging flame must it be from which such immense forked tongues can be constantly shot forth! We need no longer wonder then at the great light and heat of the Sun. But the question arises how does the Sun *keep up* this great heat through so many thousand years? Is it being burnt up, and if so, will it not be, at some day,

entirely consumed, and nothing left of it but its own ashes, and we then be left in darkness and freezing cold? These are indeed grave questions, but, happily for us, they need cause us no anxiety. For six thousand years at least, the Sun has shone on with the same splendour, and we may safely conclude it will do the same for many thousands, and perhaps millions of years more. But *how* is this mighty storehouse of light and heat kept supplied with material for fuel? The answer is this: The Sun is at least seven hundred and forty times larger than all the worlds belonging to our family of worlds, *i.e.*, the Solar System. Now, by his great mass of matter he has such superior attractive power that he draws every member of this family of worlds with sufficient force to keep them all in proper place. But the *smaller* bodies that are moving by millions on millions through space, he attracts with such great power that, instead of moving *around* the Sun, as do the larger worlds, they are drawn to the Sun, and dash upon its surface with great force. This sudden collision would of itself produce great heat, just as when a flint strikes steel, the blow breaks off a small particle of the metal and so heats it that it takes fire and appears as a spark, and will ignite tinder or powder. Now there are known to be many millions of smaller bodies moving through space, and as the Sun itself is constantly travelling at the rate of 33 millions of miles per annum, it is constantly seizing upon these numerous wandering masses, so that they are constantly dashing with frightful force upon its surface. Once there, they are first melted, and then consumed in the intense heat at the Sun's surface. And this is the way fuel is supplied to keep up the heat of this most wondrous Sun. Often these small

bodies fall to our world and are seen as blazing meteors, or meteorites, in the sky, sometimes exploding with a terrific report just before they reach the earth. Only a few weeks since one of these mysterious bodies fell in Iowa, U.S., making a hole ten feet in diameter and fifteen deep. It was intensely hot, and continued hissing and exploding for some time, and it was several days before it cooled down so as to he approached with safety. Another fell in Siheria sometime since, and was so large, and its heat so intense, that several days elapsed hefore it could he closely examined, though deeply buried in the earth. In the cahinet of Yale College, America, there is a meteoric mass of pure iron weighing about seventeen hundred pounds. When it reached the earth it must have been at a white heat, as nearly all the dross has been consumed hy exposure to a high temperature.

Now, as these hodies are often attracted hy our comparatively small globe, so as to dash upon its surface with great force, we must conclude that a vastly greater number fall upon the Sun, as that hody is about 1,260,000 times larger than the Earth, and therefore has far greater attractive power.

While two astronomers in Europe were ohserving the Sun with their telescopes, suddenly there was a most intensely hright light seen on its surface, and they hoth supposed that the coloured glasses in their instruments were cracked, allowing the strong light to pass through, causing pain to their eyes. But to their surprise, they found their glasses were not cracked; and on examining the self-registering magnetic apparatus they discovered a most extraordinary disturbance of the instruments, while at the same instant the telegraphic registers were wholly unfitted for work, and, in some instances, the buildings con-

taining them were set on fire by the electric current, though there was no thunder-storm at the time. It was afterward found that even in Europe, Australia, and the United States, the telegraphic wires were greatly deranged. Now for the cause of all this. As the intensely bright lights were seen in the telescopes at the same instant that the magnetic and telegraphic apparatus were so seriously injured, it was very justly concluded that the dazzling light seen on a part of the Sun's face was caused by an immense solid body that had been drawn from its paths, millions of miles distant, and had rushed with fearful momentum into the Sun, dashing with tremendous force upon its surface, producing a collision frightful to contemplate. This sudden collision had produced in an instant a vast amount of heat and light, and this, in turn, had excited intense electrical action, and in this way the magnetic and telegraphic apparatus was thus strangely affected, even over the whole world. Thus we see how closely connected with the Sun we are.

It has been also supposed that the *contraction* of the Sun produces a part of the heat, but this is not so clearly established as the theory just given. Electricity must be a source of considerable light, for where there is such ceaseless raging of the elements there must be enormous friction, and friction always produces electricity, so that we may safely infer that there are *continuous* flashes of lightning, and a *ceaseless* roar of thunder, equalling in violence and intensity ten hundred thousand thunder storms of Earth all concentrated in one.

We gain a faint conception of the immense amount of heat thrown out by the Sun by a simple experiment with a small lens, or common "burning glass," of

about two inches diameter. The heat collected by such a glass and brought to a focus, is sufficient to light a cigar and produce a blaze; while a lens of twenty inches diameter will collect sufficient heat to melt not only iron, but even some of the rocks. What, then, must be the amount of heat falling upon the surface of the Earth, 8,000 miles in diameter? Furthermore, it must be remembered that the Sun warms and illuminates all the other planets of our family of worlds; and still more, that an inconceivably greater amount of heat is radiated in empty space, where there are no worlds to receive it. The same remark will apply to the *light* of the Sun. The intensity of its light is one hundred and forty-six times greater than the oxy-hydrogen, or calcium light, so intolerably bright even to the strongest eye. And yet this calcium light, when placed before the Sun, is seen as a *black spot* upon its surface. Hence we learn that the black spots seen on the Sun's face may not be *actually dark*, but only *comparatively* so.

But there are other forces operating on the Sun of which we can have no adequate conception. We have referred to tongues of flame 50,000 *miles* high. But these sink into insignificance compared with those wondrous eruptions seen from the Sun's surface. If one of our volcanoes should throw matter a single mile into the air, it would be regarded as a most amazing phenomenon; but when we see a huge column of luminous matter, several thousand miles in diameter, rising to the astounding height of *one hundred and sixty thousand miles* (160,000), we may well be overwhelmed in amazement, and exclaim:

"What hath God wrought!"

These columns of various height, and form, and diameter are *constantly* seen shooting up and out from

every side of the Sun, and falling back to its surface as does the water of a fountain. Sometimes they spread out at their upper surface as do our clouds, and remain suspended for some time, indicating that some of the erupted matter is very light, and that there is probably some kind of an outer atmosphere of the Sun, sufficiently dense to hold suspended this matter, whatever it be, as our air holds the clouds above the earth.

Now let it not for a moment be supposed that all this is mere conjecture. These wondrous columns which formerly were supposed to be visible to us only during *total* eclipses of the Sun, can now be seen and accurately measured with suitable apparatus on any clear day; and photographs of the Sun are being constantly taken by astronomers, exhibiting these most astounding phenomena.

Indeed, the *whole* surface of the Sun appears like the Ocean in a furious storm, when mountain waves are raging and tossing in wild confusion, and dashing with terrific force against the rock-bound coast.

But this only faintly illustrates the rage of elements on the solar surface. The ocean waves rise only about a hundred feet, while the waves of fire on the Sun dash up and out in every direction, more than *fifty thousand miles* in an incredibly short time.

Such then is this wondrous body, the Sun. A molten, or white hot mass, 856,000 miles in diameter, equalling in bulk 1,260,000 worlds like our own, having a surrounding ocean of gas on fire, 50,000 miles deep, tongues of flame darting upward more than 50,000 miles; volcanic forces that hurl into the Solar atmosphere luminous matter to the height of 160,000 miles; drawing to itself all the worlds belonging to our family of planets, and holding them

all in proper place; attracting with such superior force the millions of solid and stray masses that are wandering in the fathomless abyss, that they rush helplessly toward him and fall into his fiery embrace. And thus he continues his sublime and resistless march through his mighty orbit, having a period of more than 18 millions of years.

How awfully grand is all this! How sublime the operation of these tremendous forces! How insignificant appear men and all their petty affairs! How overpoweringly great that Omnipotent Being, who created all these vast worlds, and gave birth to these mighty forces, and who holds them all in His hands so that they are obedient to his will!

OUR WONDERFUL WORLD.

Our world was once a buge globe of *liquid fire.* It was, in fact, a small *Sun;* probably not as brilliant, nor as intensely heated as our Sun, even in proportion to its size, yet throwing out an immense volume of heat, which must have been very sensibly felt by any near object.

We have ample proof that it was once in a partially liquid state, by its present form—an oblate spheroid —that is, a body not perfectly spherical, but flattened at the poles.

Now the earth is so flattened at the poles that its equatorial diameter exceeds its polar by twenty-six miles. How came it to be thus flattened? When a body composed of soft, yielding matter is made to revolve rapidly on a given axis, the yielding substance will tend towards the point *farthest from the axis,* because that part moves faster than any other. This is illustrated by the familiar fact of water flying from the *tire* of a carriage wheel, or from the *ridge* of a grindstone when revolving with great rapidity, as *there* is the greatest *centrifugal* force, that is, the greatest tendency to fly from the centre. The earth, then, being thus depressed at the poles, and matter being accumulated at the equator, must bave been once in a soft yielding condition. But it could not have been made thus soft or plastic by water, as there is not sufficient water on the globe to reduce the whole

mass to such a semi-fluid state. We are forced then to the conclusion that, as we find the earth having such oblate shape, and as water could not have sufficiently softened it, that it must have been thus partially liquified by *heat*—the only other agent that could thus soften it.

But we have still more conclusive proof that the Earth was once a globe of liquid fire, in its *present internal* condition. It is *chiefly a globe of liquid fire to-day.* This is proven by volcanic eruptions constantly occurring on so grand a scale—pouring out immense rivers of molten matter, extending many miles over the earth's surface, and often into the sea. These occur, too, on *all sides* of the Earth, proving that the heat of the interior is not confined to a *single locality*, but probably extends throughout the entire mass. So, also, the numerous *hot springs* in various parts of the world, corroborate this evidence from volcanic action.

We have, then, the startling fact established, that our globe is *still, to-day, mostly a globe of liquid fire;* and we live upon, and daily walk over this same globe of liquid fire! We cannot but ask, with some anxiety, how *far* are we from this world of fire? What is the *thickness* of this crust on which we live, and which is all that protects us from this terrible, raging heat over which we daily tread? The thickness is variously estimated, as measurements vary in different localities; but none given exceed a hundred miles, and many are only forty; and this is the only wall of separation between us and a most horrible death.

Verily we are treading on a mere egg-shell, then, as we walk over the so-called solid Earth. We are often most painfully reminded of this by earthquakes, when its surface heaves and rolls like the billows of the sea.

This could not take place were the *whole* globe one *solid* mass; but these *undulations* or waves of the surface clearly show that the Earth has, so to speak, a loose *rind, detached* from the great body, so as to permit its elevation by some mighty force beneath.

The question will also arise in most intelligent minds, and not without some solicitude, is this crust *increasing* or *decreasing* in thickness? Does the intense, raging heat below us melt the *under-surface* of this comparative egg-shell, and send forth the melted matter in the form of lava. Happily for our peace of mind, the *reverse* of this is known to be true. The Earth is constantly radiating heat into space from its entire surface, and is therefore *cooling down*, and as a necessary consequence this crust is continually *increasing* in thickness, and becoming more and more stable. Hence, in process of time—a very long time—the crust will become so thick that no subterranean force can lift it, and earthquakes will cease. This has been supposed to be the present condition of the Moon, on whose surface we find numerous and vast volcanic craters many miles in diameter; but the volcanoes seem to be generally extinct, and therefore it has been concluded that the Moon, being only about one-forty-ninth the size of the Earth, has already cooled down. Quite recently, however, some changes of appearance in one of the Moon's craters has been observed, and it has in consequence been thought that possibly there may still be volcanic action on that globe.

DIMENSIONS AND SOLID CONTENTS OF OUR EARTH.

The diameter of our globe is about 8,000 miles and its circumference about 25,000 miles. Its superficial area, therefore, is about 200,000,000 square miles.

Its solid contents equal 260 billions of cubic miles. Its weight 6,069 trillions of tons. The mean density of all the various materials composing the Earth is about five-and-a-half times greater than water; that is, a cubic foot of our globe taken as a whole, would weigh five-and-a-half times more than a cubic foot of water. The matter of our globe is much heavier than the matter of the Sun, for while the *volume* of the Sun is about 1,260,000 times greater than the volume of the Earth, its *weight* is only about 320,000 times greater, so that while it would require 1,260,000 bodies of the *size* of the Earth to make one equalling the *size* of the Sun, it would take but 320,000 Earths to form a body of the same *weight* of the Sun.

THE CENTRE OF THE EARTH A GLOBE OF GOLD AND PLATINUM.

As the Earth was once, in all probability, a globe of melted matter, the various particles of matter in such a state would move freely among themselves, and the heaviest particles would naturally sink lowest. Now as gold and platinum are the heaviest substances known to us, they would, in obedience to the law of gravitation, seek the centre of the Earth, and hence there is at least a strong probability that at the centre of our planet there is a globe of these precious metals in a comparatively pure state, made thus pure by the intense heat at that point.

What is the diameter of this globe of precious metals, whether hundreds or thousands of miles, we shall here never definitely know, but as we find small particles of these metals on and near the surface, brought up in remote ages by volcanic action, and find them in combination with some of the older rocks, we may infer that this globe of gold and

platinum is very large, else so much would not have reached the surface.

HOW THE EARTH COOLED DOWN.

The question at once arises, if the Earth was once a globe of liquid fire, how came it to cool down and reach the present state?

Here we can do but little more than conjecture, and yet with some show of reason. It has been supposed that the Earth passed into a cooler region of space, and by radiating its heat a crust was gradually formed on its surface. This crust was often broken by the frequent and violent upheaval of the molten mass, and the attrition or rubbing together of the rocky fragments wore them down, and thus furnished materials for the soil. These volcanic eruptions must have been of very frequent occurrence, as the thinness of the crust at first made it easy of fracture, and probably, instead of the *twenty* annual eruptions *now* experienced, many *thousands* occurred then in the same time, the ejected matter flowing over the older rocks, and thus daily increasing the thickness of the crust. At length, when sufficiently cool, the watery vapour, which must have thus far enveloped the entire globe as intensely heated steam, and to a great height, began to condense and fall in constant and heavy showers, until seas and oceans were formed, the atmosphere cleared of the most dense of vapours, when the sun shone forth, and vegetation appeared. From this it will appear very evident that our globe must have a very great antiquity, as it would require many thousand ages for the Earth to cool down, and go through these various changes. This is illustrated by the time required for the cooling of large castings, as the great bell of Moscow, which was several weeks in reaching a temperature to justify its use.

This huge mass is dashing through space at the rate of about 66,000 miles each hour. During an eight hours' sleep we more than travel the distance of the Moon and back again. One cannot but shudder at the thought of a collision with some other body of corresponding magnitude moving in an opposite direction with the same frightful velocity. But infinite wisdom and divine goodness have provided against so dreadful a catastrophe, so far as respects *our family* of worlds by making them all move in the *same* direction around the Sun, and at vast distances from each other. In performing this journey, we then, though seemingly stationary, are travelling each hour 66,000 miles. What a marvel is it that in this rapid flight the clouds and the atmosphere are not left behind!—that we ourselves are not constantly dropping off the planet and left to fall, and fall forever in vacant space! But the same infinite wisdom and goodness have prevented this by giving to the Earth such *attractive power* that clouds and atmosphere, and men and all living things are held firmly near to or on the surface.

In thus dashing through space, we perform annually a journey around the Sun of nearly six hundred millions of miles. But this is not *all* the travelling we do in the course of the year. As the earth revolves on its axis once in twenty-four hours, and as the circumference is 25,000 miles, an inhabitant on the Equator travels in one year by this daily revolution 9,125,000 miles. Nor is this all. As the Sun itself has already been shown to be revolving around some far-distant, and as yet, unknown centre, at the rate of 150,000,000 miles each year, requiring more than 18,000,000 years to complete one revolution, the Earth necessarily accompanies him in his mighty

journey, as do all the other members of our world-family, so that this also is to be added to our journeyings through the vast abysses of space. The aggregate of these various journeys for a single year is 759,125,000 miles. And we perform this long journey of more than three-quarters of a billion of miles each year, not only without accident, but without even as much jar as the infant feels from the pulsations of its mother's heart while resting on her breast.

What human power could devise such locomotion? What evidence of Divine Wisdom and power to plan and execute such a means of transportation, and make it subserve so many important ends!

Let us suppose that these mighty wanderings were attended with the same discomfort experienced in our most luxurious modern conveyances, or even the thousandth part of it, and how tolerable would life become. But so quiet and noiseless are those vast movements, that by far the large majority of the human family are wholly unacquainted with them; and even those who have made us aware of them have been obliged to labour long and hard to make the discovery.

So perfect are the works of God.

A DAILY WONDER.

That such a huge body as our globe should completely turn around its axis every twenty-four hours, causing our heads to point in the direction of our feet; turning all the wells and rivers, and seas and oceans bottom side up, and placing the foundations of all the buildings where their roofs should be; that all this should take place every few hours, was once deemed so monstrously absurd, that those teaching it were regarded as beside themselves, and guilty of

subverting the divine oracles of God. Galileo, the Astronomer, was most cruelly persecuted by the Pope of Rome for doing this, and compelled, upon pain of death, to deny his own teachings. But all this is now clearly proven, and yet many are wholly unacquainted with the proofs. I notice but breifly the more common proofs of the *apparent* revolutions of the Sun, Moon, and Stars around the Earth, simply remarking that it is preposterous to suppose that these millions of immense bodies at such immense and *various* distances, should all have their periods of revolution so exactly timed as to simultaneously revolve around our comparatively insignificant globe.

If we ascend to the top of a lofty monument, and drop from the summit a pebble, it will not fall to a point exactly beneath our hand, but a little to the *east* of it. How is this explained? Only by the revolution of the Earth on its axis. The *top* of the monument being farther from the centre of the Earth than the base, it describes a larger circle than the *base*, but it describes it in the *same time*, therefore the *top* of the monument moves *faster* than the *base*, and consequently has a greater tendency to throw a body forward than has the base. Now as we find the pebble always falling *east* of the point from which it fell, we can account for it only by supposing that the Earth turns on its axis from the west to the east.

Again, if we take a clock from a high latitude to the equator, we shall find that it is too slow; but if returned to the high latitude it will again keep good time. This can be explained only by attributing it to the same cause of increased rapidity of motion. The clock at the equator is farther from the Earth's axis than when nearer the pole, and therefore describes

a much larger circle than it did in its northern home; but it describes it in the *same time*, and hence, must travel *faster* than before. Now this more rapid motion will tend to throw it from the surface with more force, and hence the attractive power of the Earth is somewhat overcome, and the *weight* of the pendulum is *decreased*, and therefore moves *slower*—a clock from London losing one hundred and thirty-five vibrations in twenty-four hours. So we find *all* bodies weigh less at the equator than in higher latitudes, always losing one pound for every 290 pounds, and this because at the equator they describe a circle of 25,000 miles circumference in twenty-four hours, while in higher latitudes the circles vary according to their distance from the equator; and at the poles describing none at all, but being perfectly stationary. Did our globe revolve on its axis in 84 minutes, bodies at the equator would have *no weight;* and if it revolved in *less* time, then they would be hurled out into space, just as water is thrown from the tire of a carriage wheel when revolving rapidly.

How happens it that we have such an exact adjustment of these opposing forces that bodies are retained upon the Earth's surface, and safely guaranteed to us all? Is this the result of chance? And so that most remarkable fact, the attractive power of the Earth, is exactly adapted to an animal's strength. Thus, the Earth's attraction of the elephant is far greater than its attraction of a rabbit, and its strength is proportionately increased.

We commonly say, the strength of the animal is greater because his *weight* is greater. But *weight* is wholly the result of the earth's attraction. How happens it that this attractive power of the earth is *invariably* in proportion to an animal's strength?

Suppose a rabbit, or even a man, to be attracted with the same force as an elephant. Then the rabbit and man would be chained down in utter helplessness to the surface of the earth, wholly unable to move even a single finger or limb. But we find a universal law operating; namely, that all bodies are attracted in proportion to their quantities of matter, and hence we find the rabbit and the man not attracted as is the elephant, but only in proportion to their muscular strength, and so are able to carry their bodies without inconvenience over the earth's surface, while the ponderous elephant also does the same. Whence this law? Is all this mere chance? Does it not clearly show a *Great Originating Cause*, and also prove that *Cause* to be not only all-wise but all-powerful and beneficent? He who denies this cannot claim to be of sound mind, nor of right heart.

WHAT IS THE MOON?

There are more asking this question, mentally, than would be willing to acknowledge it. With all the knowledge of professional business, there is often a most lamentable ignorance of the most common phenomena of the natural world. But why should men go through the world, and remain almost as ignorant of the wonders above and around them as dumb cattle? How much more would they enjoy nature if better acquainted with it. Night is invested with peculiar charms to the student of science, even though he be but a novice in it. Even a thoughtful savage must be impressed by "the Moon walking in its brightness," and majestically marching in silent grandeur among the Stars; and her frequent and mysterious changes of place and form, must fill his mind with solemn awe. We need not then wonder that her matchless beauty and valuable service as Queen of Night, have so often inspired devotion in untutored minds, and led them to render her divine honours.

An effort to learn more of the mysteries of this wonderful object will be amply repaid.

At the outset, we must understand that the Moon, though giving us so much light, is, nevertheless, a dark body like our earth. It is probably composed of materials such as go to make up our globe, all of

them non-luminous, and affording not a single ray of light.

How, then, does she appear so beautifully bright? Simply by *reflecting* the light falling on her surface from the sun. Like our own globe, she is always warmed and lighted by the great solar orb, and appears to us full, or, in crescent form, according as her illumined side is wholly, or, in part, turned toward us. By moving a sphere horizontally around a stationary lamp, an observer, at the distance of a few feet, will see all the phases of the Moon faintly visible on the surface of the sphere. By a somewhat similar revolution of the Moon around the Earth, the lunar changes are produced, the Sun always lighting one half the Moon's surface, but the *entire half presented to us* only when the Moon is directly opposite the Sun, when she appears full to us.

WHENCE CAME THE MOON?

It has been supposed by some that the Moon was once a solid comet, and, while wandering through space, came so near the Earth that it was seized by his superior attractive power and thrown out of its path, and has been ever since held by the Earth in his giant grasp, and compelled to do him service as a revolving satellite. This, however, can never be demonstrated. Another theory to which we shall hereafter more fully refer, is that the Moon was formed, as was the Earth, from nebulous, or very thin matter, diffused through space, and condensed into solid form about the same time that our globe was moulded into its present shape. If the theory of its cometic origin be true, we may, at some day, arrest another comet, and our world be favoured with two, or even more Moons, as are some of our sister worlds.

Or, should a *larger* body than the Earth pass near the Moon, it might seize upon her and carry our beautiful Queen of Night away from us into the unknown abysses of space, never more to return to us. But all this is highly improbable, and our fears may be regarded as groundless in view of the divine declaration, "He hath *appointed* the Moon for Seasons;" and we may safely assume that she is thus "*appointed*," at least, as long as the race of man needs her service.

IS THE MOON INHABITED?

Reasoning from what we know of the necessities of animal life, we should unhesitatingly answer, No. There is no atmosphere on the Moon, and if no air there can be no clouds, and therefore no rain; and if no rain, no vegetation, and if no vegetation, nothing to support animal life. But how do we know that there is no atmosphere in the Moon? Thus: When the Sun, Moon, or Stars rise or set, we always see a perfect *image* of them while they are actually *below* the horizon, and, of course, out of sight. Thus, when the Sun is seen resting his lower edge on the horizon, it is not the *Sun itself* we see, but only his image. The same is true of the Moon and all the Stars. This remarkable fact is owing to the *refractive* power of the atmosphere by which the rays of light are bent out of their course the moment they enter it, and in this way *images* of all the heavenly bodies are presented to us before they rise, and remain with us after they have set.

Now, if the Moon had an atmosphere, we should witness the same phenomenon there. When a Star disappeared behind the Moon it would not pass *instantly* out of sight, but its image would linger, as

in our atmosphere ; but, instead of this, we invariably find an *instantaneous eclipse* of the Star, and no appearance whatever of the lingering image, and hence we are compelled to infer that there is no atmosphere on the Moon, and must accept all the conclusions resulting from it.

True, there may be animals entirely different in constitution from those of our globe, but of this we have no evidence, as the most powerful telescopes cannot inform us respecting such small objects. The general aspect of the Moon is unfavourable to the supposition that it is now inhabited. As seen with our largest instruments, its surface is exceedingly broken, as if it had been subject to far more violent volcanic action than our globe. In *proportion* to its *size*, the mountains are much higher than those of the Earth, some reaching an elevation of 23,000 feet, nearly as high as the Himalayan range. Frightful precipices abound, one, at least, rising perpendicularly 16,000 feet. There are also numerous crater-like mountains, having concentric rings—rings within rings—having a diameter of more than fifty miles. In the centres of these immense craters are often distinctly seen mountains of great height—mountains within mountains—seemingly formed by the volcanic matter formerly thrown out, and which fell back into these vast craters. Some of these are greatly depressed below the general surface, often sinking as low as 4000 feet. These depressions are the dark parts of the lunar surface so distinctly seen by us, and not seas and oceans, as formerly supposed, while the brighter portions are the more elevated.

It has generally been admitted that volcanic action has long since ceased on the Moon. Some recent observations, however, on a particular crater seem to

have revealed some change of aspect, and hence it has been thought that that particular volcano may possibly be in a state of eruption. As we have never seen but *one side* of the Moon, and never shall see the other, it is impossible for us ever to know what is transpiring on the opposite side.

This one-sided view of the Moon is owing to the fact that it revolves on its axis in exactly the same time that it revolves around the earth. This will be understood by revolving a ball *once* on its axis while it moves *once* around a fixed point.

DISTANCE AND MAGNITUDE OF THE MOON.

The Moon, though apparently as large as the Sun, is, in reality, the smallest heavenly body visible to the unaided eye. Her diameter is 2164 miles.

As spheres are to each other as the cubes of their diameters, it follows that the Moon is only one forty-ninth the size of the Earth, the Earth's mean diameter being 7912 miles.

Seventy millions of such globes as the Moon would be requisite to make one equal to the Sun.

The reason why the Moon appears as large as the Sun is because of its nearness, its distance being only 240,000 miles, while the sun is about 92,000,000 miles. The Moon then is by far the nearest of all the heavenly bodies. Her distance, however, is not always the same, but changes, so that at times it is thirty thousand miles less distant than at others.

Were there a railroad to the Moon, it would require five hundred days to make a journey there, travelling night and day without stoppages, at the rate of twenty miles an hour.

In consequence of the Moon being only one forty-ninth the bulk of the Earth and about eighty times higher in proportion, bodies on her equator would weigh much less than on the surface of the earth, because there is less matter acting on these bodies to draw them to the centre of the Moon. For example, a man on the Earth weighing 125 pounds, on the Moon would weigh only 20 lbs., so that if his strength remained the same, he would be able to leap with ease over the tops of the tallest trees of the forest. On the other hand, if a man weighing 200 pounds were transferred to the Sun, he would weigh 5580 pounds, and if his strength remained only the same, he would be chained down to the surface in utter helplessness, as shown in another article. Were this same man, weighing 200 pounds on the earth, placed on some of the other Suns, which are ordinarily called Stars, he would weigh more than one hundred thousand pounds. If he were placed on some of the Asteroids—the smallest globes of our own family of worlds—the same man of 200 pounds would not weigh more than two or three pounds. All this will be understood when we remember the universal law, that all matter attracts other matter in proportion to its quantity, and further, that all matter is attracted to the *centre* of a globe, where attraction virtually ceases, and the body has *no weight*, because it is attracted *equally* in *all* directions. Hence, were the earth a hollow sphere, a body placed in its centre would remain perfectly *at rest*, *supported upon nothing*, but stationary in the centre of that empty space.

It will then be seen, that as the Earth's diameter is, say 8,000 miles, there are 4,000 miles of matter drawing a body on its surface to its centre; while, as

the Sun's diameter is, say 8,800,000 miles, there are 440,000 miles acting on a body lying on its surface and drawing it to its centre. And, as some of the Asteroids are only about forty miles in diameter, there are only twenty miles of matter attracting bodies on their surface.

From this it will be clear why bodies do not have the same weight on different worlds.

So also from the same cause, bodies would fall to the surfaces of these different worlds with different velocities, *i.e.*, because attracted by different forces. For instance, a pebble that would fall to the Earth about sixteen feet in a second would fall to the Sun about 440 feet in the same time; while the same pebble would fall to the surface of an Asteroid about as fast as a feather would to the surface of our own globe.

MOTION OF MOON AROUND THE EARTH.

The Moon revolves around the Earth from west to east in 27 days, 7 hours, and 43 minutes. This is called a *sidereal* month, because she then returns to the same point among the Stars.

But while the Moon has been completing one such revolution around the Earth, the Earth itself has been moving through space in the same direction—from west to east—and therefore the Moon must advance about two days longer in her orbit, or path, in order to *appear to us* to have completed a revolution. This is called a lunar month, or formerly, *moonth*, from which comes the word now used—month.

This lunar *moonth*, or month, is 29 days, 12 hours, and 44 minutes long.

As the Moon is advancing, daily, from west to east, in her path around the Earth, about thirteen degrees,

it follows that the Earth must make more than one complete revolution on its axis, in order to bring the same spot directly under the Moon. Hence the Moon rises later each day about fifty minutes, as the Earth must turn on its axis that much longer to have the Moon directly over any *particular place* of the earth.

THE HARVEST MOON.

There is a remarkable exception to this daily later rising of the Moon, which occurs during the autumn, when it rises only about *twenty* minutes later for several days. This would seem to be a special and merciful provision of a kind Providence for the purpose of lengthening the day at a period when time is often exceedingly valuable to the husbandman, thus permitting him to gather the fruits of his year's toil, and while exempt from the scorching heat of the Sun.

LUNAR INFLUENCES.

It is very generally supposed that the Moon exerts a great influence upon animals and plants, as also upon food when prepared at particular phases of this body. Thus, many imagine that trees must be felled, seed planted, animals slaughtered, and medicines administered at the full, or at the waxing or waning of the Moon. But all this is mere superstition, and is wholly without support, either from philosophy or fact. The same remark will apply to the Moon's influence upon the weather, long and careful observation having proven that atmospheric changes are wholly independent of lunar influence. The Moon's light upon the eyes of sleepers seems to produce unfavourable effects in oriental nations. There is, however, a

most powerful and beneficent influence exerted by the Moon in producing the daily tides. The Sun raises a tidal wave, also, but, on account of his distance, it is only about one-third that of the Moon, so that the Moon is the chief agent in producing these most wonderful ebbings and flowings of the great world of waters. But this is too important, and too beneficent an arrangement of our merciful and all-wise and all-powerful Creator, to pass over slightly, and we must make it the subject of a special article hereafter.

EARTH LIGHT.

When the new Moon is seen in a clear sky, a dim globular light is observed resting in the crescent or bowl of the Moon, and is generally termed "the old Moon in the new Moon's arms." This was long supposed to be the *native* light of the Moon, but it is now known to be the reflected light of the Earth.

To understand this, it must be borne in mind that our world appears in the Moon's sky, just as does the Moon to us, but with this difference—the Earth presents to the lunarians (supposing for the moment that the Moon is inhabited) a glorious orb about thirteen times larger than the Moon appears to us. This globe, therefore, is a most resplendent object in the lunar sky, and affords about thirteen times as much light as does the Moon to us. It is this light of the Earth received from the Sun that we see faintly outlining the Moon's form to us—"a reflection of a reflection" giving us some idea of the comparative strength of the direct and reflected rays as received on the Moon.

It is among the possibilities, that the Moon may at

some time have an atmosphere by seizing some wandering gaseous comet, composed of the proper elements, and holding it ever after as a part of its own matter. Should such a gaseous body he thus snatched from its orbit as it dashed by with lightning speed, it would immediately envelope the whole surface of the Moon as does our atmosphere the Earth, and would probably soon effect important changes over the entire lunar surface. It is possible that the atmosphere of our own globe was thus furnished by some one, or more of those fugitive worlds, while rushing wildly through space.

But this we shall never be able to prove. This, then, is our beautiful Queen of Night. How much of human enjoyment is due to her presence. How cheerless would be the long winter nights if left without her presence. And how disastrous to the inhabitants of Earth, were the waters of the vast oceans no longer purified by her disturbing influence! And does it not exhibit the most wonderful wisdom and power, that such a huge body, weighing so many millions on millions of tons and placed so near us, can move harmlessly over our heads, day after day, and week after week, and year after year, without falling to Earth and crushing and shattering our thin, egg-shell of a crust, and letting out the hissing, raging molten mass beneath, in one universal deluge of liquid fire?

What but Omnipotence *can* do all this? What but infinite Love and Beneficence WOULD do it, and daily make that a charm, a fascination, a delight, which could and *would* in an instant, without His gracious interference, become a direful and most awful curse!

Let us be grateful that we are not left to be the

sport of a blind and fickle chance, but that Jehovah reigneth, not only in Heaven, but as the All-wise and Merciful Disposer of events below, and that He regards with profound interest, the minutest events in the history of each one of His intelligent creatures of Earth.

WHAT ARE THE STARS?

No. 1.

No human being, probably, ever looked heavenward without, almost unconsciously, asking himself this question, and yet, strange to say, thousands have gone through a long life without ever earnestly seeking an intelligent answer.

It is the more strange, as no scene of Earth is so impressive and so sublime as the heavens on a clear night, when all the glorious constellations are out in their full splendour, and seem, by their incessant twinkling, to be ever exchanging signals with their fellow-stars on the outskirts of the universe. And what rational being can contemplate these mysterious bodies and not be awed by a sense of a Supreme and Almighty Intelligence? It would seem as if the midnight assassin, with those myriad worlds looking down upon him in all their silent majesty, must be arrested in the very act of crime.

But, unfortunately, to the *masses*, the wondrous character of these worlds is unknown, so that a view of the heavens, in all their glory, excites no higher emotions than are awakened by a gaudy picture, or by the tinsel of the play-house. But an *intelligent* survey of the heavens excites emotions of a far different character. To distinguish system from system, and world from world; to be acquainted with their

various and wondrous phenomena; to find ten thousand Suns—each superior to our own—crowded into a comparative point of space, and yet separated by distances beyond human conception; to penetrate the unfathomable depths above, beneath, and around us, and everywhere find new worlds bursting upon our view with each increase of telescopic power—this must give us higher views of Omnipotence, and overwhelm us in unutterable astonishment at the vastness of Jehovah's empire.

BUT, WHAT ARE THE STARS?

Here Science answers with no faltering voice, and the answer is, "they are all *Suns*, many of them thousands of times greater than our Sun, and affording vastly more light and heat than does our Sun." Were our globe placed as near to some of these Stars as it is to the Sun, all animal and vegetable life would not only be destroyed, but all metals, and even the very rocks would be melted, and the whole mass reduced to a molten or liquid state, as it was thousands of years before it cooled down and assumed its present form.

Now let us see if there is any satisfactory proof of this startling assertion, that the Stars are *all* Suns, and, in some instances, thousands of times larger than our own Sun.

And first we have this proof in the fact that they are *visible* to us, notwithstanding their immense distance. *Reflected* light—*i.e.* light like that of the Moon—has, comparatively, but little power to penetrate space.

For instance, the planet Neptune--the outermost planet of our family of Worlds—is about 2,750,000,000 miles distant; but, although more than a hundred

times larger than our World, and having a diameter of 375,000 miles, yet not one ray of its light reaches our *unaided* eye, because that light is the *borrowed* or *reflected* light of the Sun, like the Moon's. Now let it be borne in mind that the *nearest* Star is many millions of times more distant than the planet Neptune, and yet, while by the naked eye no trace of Neptune can be seen, the Star is distinctly visible *without* a telescope, because it shines, not by reflected, but by its own native light.

HOW DO WE KNOW THAT THE STARS ARE SO DISTANT?

This question is proper; we will endeavour to answer it. The distance of the Stars is proven by the startling fact, that we cannot in the least degree magnify them, even with our *largest* telescopes. If, for instance, we point a large instrument to a *planet* —which *appears* like a Star—that planet is magnified to the size of the Moon; but if we point the same telescope to a *Star*, we find its *brilliancy* only is increased, while its *magnitude* remains precisely the same. This is true, however powerful the glass used. There will *apparently* be some increase of diameter; but it is only an optical illusion, as is proven by the very remarkable fact that if we draw a single spider's thread across the glass of the telescope, that spider's thread will completely *cover* and entirely shut out from view the Star. This proves that the Star is not in the slightest degree magnified, but, when seen, even through Earth's mightiest instrument, is a mere *point* of light.

Now let us endeavour to understand what the telescope does for us in an observation like this. We will suppose the glass has a magnifying power of one thousand. Then, it, in effect, brings the Star a

thousand times nearer to us; or, what is the same thing, it is as if we were taken up bodily and transported over the abysses of space to within one thousandth part of the whole distance, and there set down, and from that comparatively *near* point, were allowed to make a new examination of the Star; but such is the mighty distance of the body that even that small part of it is too great to permit us to see any change whatever in the Star, save that its *brilliancy* is increased.

The fact, then, that the largest telescope cannot magnify a star, while the same instrument will apparently convert a *planet* into a Moon, is proof of the immense distance of the star.

But there is other startling evidence of their great distance. Let us first recall the fact that our globe is revolving around the Sun from west to east, at a distance from the Sun of about ninety-two millions of miles. Now, when the Earth is on the west side of the Sun, let us select a star in the western sky, and carefully measure its light with that new and delicate instrument, the photometer, or light measurer.

Then we will wait six months until our globe has passed through one-half of its orbit or path, and has gotten around on the *east* side of the Sun. It is now twice 92 millions of miles from its former position where we first measured the light of the star; that is, it has removed 184 millions of miles farther from that star. Now let us again apply our photometer and carefully measure the same star's light, and we find, to our utter amazement, that it has lost none of its brilliancy; it is as if we had not receded a hair's breadth from the noonday Sun—there is not the least perceptible loss of light. So, if we reverse the process, and while our globe is on the *east*

side of the Sun, measure the light of another star in the west, and then, waiting six months again, until we have passed around to the *western* side, and are 184 millions of miles *nearer* the star, and then again apply the photometer, we shall again find no change of brightness—the star will appear no more brilliant than when we were 184 millions of miles farther from it. This also shows that the body is immensely distant, because the distance of 184 millions of miles is as *nothing* to the *whole*—the change of position effecting not the least change in the appearance of the star. There is still another striking proof of the great distance of these bodies. While the Earth is on the west side of the Sun, let us select a star in the *south*, instead of the east or west. We will then take a telescope, and will draw two fine spider's threads across the glass at right angles to each other. Then adjusting the instrument so that the star shall be exactly at the crossing point of the spider-threads, we will firmly fix the telescope so that it cannot be moved, and wait six months, until the Earth has passed to the east side of the Sun, 184 millions of miles OUT OF RANGE, and to our astonishment we find that same star is still on the point of intersection of those same spider-threads; the removal of the instrument 184 millions of miles OUT OF RANGE has not in the least affected the apparent position of the star—it is still in as PERFECT RANGE as when the telescope was first adjusted. We shall the better understand and appreciate this most extraordinary fact when we remember that if a rifle be aimed at a mark, and then be shifed *half an inch* to one side, it is thrown out of range; but here a shifting of 184 millions of miles produces not a change of even a hair's-breadth.

Now all this proves most conclusively, that the

stars are at immense distances from us. But we have seen that *reflected* light cannot be visible at like distances. Now as the stars *are* so *distinctly seen* by us, notwithstanding the great spaces that separate them from Earth, we are forced to the conclusion that they all shine by their own native light; in other words, they are all Suns. This, then, is a settled point.

THE NEAREST STAR.

The Star nearest to the Earth is the Sun; for the Sun is nothing but a Star, apparently larger and brighter than the others, but only so because so much nearer. Were the Sun as far removed from us as some of the Stars, it would not only dwindle in size and brilliancy, but would be entirely lost to sight—not one ray of its light would ever reach our world. The distance of this body from our globe is about 92 millions of miles. Light, moving 182,000 miles a second, is eight minutes in reaching us from the Sun. Hence the Sun has risen eight minutes before we see him. A cannon ball would reach this distant globe only after seven years of undiminished speed. A railway train, moving constantly day and night, thirty miles an hour, would be 350 years in making the journey to the Sun.

The next Star in order of distance is Alpha, of Centaurus, the constellation represented by the figure of a half man and a half-horse. This is the one whose distance has been accurately determined; and this is so deeply buried in the abysses of space that eighteen and a half trillions of miles must be passed over before it would be reached. What a vast void is there then between the outermost world of our family of worlds and this far distant Star. We can hardly repress a feeling of loneliness as we think how far

removed we are from all these glorious worlds above, beneath, and around us.

The distance of some other Stars is vastly greater. Let us take one of the sixth magnitude; that is, one just visible to the *unaided* eye. Let it be borne in mind that our globe is dashing through space at the mean rate of 66,000 miles an hour—it is sometimes more, sometimes less, according as we are nearest to, or farthest from the Sun. Now let us suppose our globe, instead of continuing to revolve around the Sun, to start from its orbit and rush in a straight line toward this Star of the sixth magnitude, and how long would it be in reaching it? 7,200,000 years must pass away before it would be sufficiently near to receive from that Star, or Sun, the light and heat we now enjoy. What a merciful provision of Providence that our own and other worlds cannot thus fly from their orbits and plunge wildly into the freezing depths of space, depriving us of all the light and heat of our beautiful and genial Sun!

But there are other Stars even more distant. With our greatest telescopes, numerous nebulæ—that is, cloud-like bodies—have been discovered, and so remote, that light from them travelling 182,000 miles each second, can reach our planet only after the lapse of 3,500,000 years.

And yet, these are not even the *outskirts* of creation. We have every reason to believe that beyond these remote worlds there are hundreds of thousands more, equally grand, and as far from them as they are from us, and only waiting for larger telescopes to bring them to our astonished view, and overwhelm us by their amazing splendour.

Let us here notice a very interesting fact. We have already seen that light is not *instantaneous* in

its passage through space, but requires time, although its velocity is so startling. Now this being true, it follows that the light we receive *to-day* from these heavenly bodies is the light that left them five, fifty, a hundred, or a hundred thousand years ago, according to their distance; and so the light that leaves them to-day will reach our globe only after the same number of years have passed away.

From this it will be seen that it is impossible for us to know the *present* condition of these bodies. They may have been destroyed long since, and the stream of light be now rushing toward us, but soon to cease in a moment; just like a long stream of water that will continue to flow after the fountain has been exhausted, or the supply in an instant cut off, but will soon suddenly cease flowing altogether, as the last water reaches its point of destination. So should any one of these Suns be stricken out of existence to-day, we should have no intimation of the fact until the *last* departure of light had reached us, and then the body's light would instantly be extintinguished to us, though really extinct long before. It will also be seen that should a new world, or sun, be created to-day, we should know nothing of it until its light had reached our globe, and this might require ten years, or ten hundred thousand, according as it was near or remote.

WHAT ARE THE STARS?

No. 2.

In our last article we considered the constitution and distance of the Stars, and learned the great truth that they *are all Suns.* Let us now ascertain our relative position to these bodies. And at the outset, we must understand that the Stars are not only above our heads, but

THE STARS ARE ALSO BENEATH OUR FEET.

Like a particle of dust floating in the atmosphere, surrounded hy its fellow particles, so our globe is surrounded on all sides by its fellow worlds, its comets and hlazing Stars or Suns. But, unlike these particles of dust, moving at random, these worlds and Stars are all placed at fixed distances, and move in regular orbits, with varying velocities.

The Stars are called "*fixed*," hecause to the casual observer they seem always to be exactly in the same place; differing in this respect from the planets, which are constantly changing their places; hence their name "planets," that is, *wanderers.*

THE NUMBER OF STARS.

There are now discovered to us by the aid of the telescope, one hundred millions of Stars.

The *actual* number is, doubtless, far greater, as in some part of the heavens the Stars are so crowded

together that they present the appearance of "commingling blazes of light, and cannot be counted. They seem like great masses of intense light, completely covering and shutting out large tracts of the sky. Had we still more powerful telescopes, we probably would discover such vast multitudes of Stars that no sky at all would anywhere be seen; but this can be proven only by larger instruments than the world is likely to see for many years to come. Indeed, we are almost forced to the conclusion that the Stars are *innumerable*—that there is no part of space where they do not flash and blaze, lighting up vast systems of worlds. We *cannot set bounds to space.* There is no part of the universe where are reared towering walls reaching up millions of miles beyond which space does not exist. We may dash down through the depths beneath, millions and trillions and decillions of miles, and continue our flight through ten thousand millions of years, and then with the wings of light press on in the misty darkness ten hundred thousand millions of decillions of ages, and in the same direction too, and there will be no barriers found to obstruct our progress, no boundaries of space, but illimitable expanse will still be stretching out beyond and beyond, and beyond—forever. So, retracing our steps, and dashing out in the opposite direction, we shall have again the same experience; and then darting off at right angles and continuing to explore through ten thousand of the measureless cycles of eternity, and in *all* directions, and we return to our starting point overwhelmed by a new conception of the immensity of space. Now in all this space we have every reason to believe the GREAT CREATOR'S ALMIGHTY HAND is to be seen in His wondrous works; and as all space *known* to us is so densely populated

with glowing worlds, so space *unknown* to us may be reasonably supposed to be equally as full of life and exhibitions of Almighty power. This, too, seems an absolute necessity growing out of the laws of matter. For instance, all matter attracts other matter, and this of course supposes that that which attracts is itself in turn attracted. Now, this being true, if there are limits beyond which there are no worlds, then the *outermost* worlds, having no attracting forces *beyond* them, would be attracted only on one side, that is, by the *inside* worlds, and therefore would in time be drawn by them into a collision with those nearest them; and then these consolidated bodies, being now the *outside* world, would be attracted as were the others by the *inner* globes, and another collision would result; and so the work of *one-sided* attraction would go on, until all the suns, and comets, and worlds would all unite in one mighty whole, which would necessarily effect the destruction of all animal creatures on these worlds, and also of the worlds themselves. But, on the other hand, if the stars be, so to speak, infinite in number and occupy infinite space, then all would be *equally* attracted in *every* direction, and hence all would keep their place, and thus harmony be preserved throughout these myriad worlds.

Let it be remembered here that each of these one hundred million of suns is, in all probability, the centre of a system like our own. Our family of worlds now numbers about one hundred and seventy worlds, including planets and satellites, or moons.

Now, as we know that many of these stars or suns are greatly superior to our own Sun, we may reasonably infer that they have as many, and probably more, worlds circling around them as there are

revolving around our solar centre. But all this vast assemblage of one hundred millions of Suns, and their many bundred millions of moons and planets may he to the *whole* universe only as a drop to the ocean, and if in a moment destroyed their loss would probably no more be noticed by an observer, who could survey the *whole* of creation, tban would be the removal cf a grain of sand from the seashore. So vast is this universe! How little is man! How GREAT IS GOD!

It will probably startle many readers to learn tbat of all these many millions of starry worlds above, beneath, and around us, about *five thousand* only are ever seen by the *unaided* eye. Seemingly, many more are visihle, but it is an optical illusion.

But when we point a large glass to the beavens, tbe cbange of aspect is most startling. We seem as if we were in a moment transported tbrougb tbe mighty profound of space, and set down in close proximity to another creation; or, it is as if another universe had suddenly sprung into being by the Almighty fiat, and was there dazzling and glowing before us, in all tbe beauty and freshness of new-born life.

THE WONDERS OF LIGHT.

How wonderful tbat ligbt *can* reach us from such remote worlds! How mysterious that an imponderable force, that is, one having no perceptible weight, even wben weighed by the most delicate apparatus science and art can construct—how mysterious that this weightless something should be capahle of outstripping in its flight all the projectiles ever invented by man, even as the gazelle or antelope outstrips the laggard slotb. Think of a ray of light setting out on

its long journey to Earth, from one of those far-off Suns far beyond the Milky Way. It started ten thousand years before Adam first looked up with delight, and yet with wondering awe, upon the glorious heavens, as he, with Mother Eve, walked the grassy groves of Eden. On it came, that ray of light; now rushing through vast systems, now passing in an instant great worlds as they too sped with frightful haste through their mighty orbits; now overtaking and dashing by raging comets, as they rushed on with almost lightning speed, their fiery trains streaming out over the profundities of the vast abyss; on it came, that ray of light, passing mighty constellations, sweeping by huge Suns with their planetary worlds, leaving star after star in the unfathomable depths behind; thus it came, that ray of light, straight on, turning not a hair's breadth either to the right or left in its long flight; and yet, when our great progenitor looked out upon the sky, that ray of light from that remote sun did not fall on his vision, for it was yet far out in the immeasureable depths. Nor when the Ark was launched upon the angry waters had it come. Nor when the Divine One appeared in human form to redeem a fallen race had that ray yet dawned on human sight; and though ever since dashing on more than one hundred and eighty thousand miles each second of time measured by the faithful pedulum, yet that same ray of light has not yet reached us, and *five thousand years more* must pass away before it can leap the great chasm that separates its source from us.

But that ray of light *will* come; its far-distant source will yet shine as a bright orb in our firmament, and in some part of the sky where now is only blank space, there will be suddenly seen a blazing star,

thenceforth to glow with its fellow suns until Heaven and earth shall pass away.

THE MAGNITUDE OF THE STARS.

We have already seen that the stars are at immense distances from us, and as they are visible to us, notwithstanding this distance, they must be suns, shining by their own native light. But this is not all; they are not only suns, but suns of immense magnitude, vastly greater than our own. This we know from the fact that they appear far brighter to us than would our Sun if placed at the *same* distance from our world as are the stars. The Star Sirius, commonly known as the Dog Star, is estimated to be two thousand times larger in volume or bulk than our sun; so that from it might be formed 2000 solar centres, each one capable of doing all that is accomplished by our own.

It must not be inferred from this that its *light* is also 2000 times greater, as Sirius emits only *three hundred times* more light and heat than does our Sun. The star Lyra in the constellation called the Harp, has been estimated to be 58,000 times greater than our Sun.

But this estimate is probably too high, though doubtless it is a most wonderful object, and must light up a system of overpowering grandeur: and yet this immense globe appears to us only as a mere point of light, without affording any perceptible heat; so deep is it buried in the unfathomable depths of space.

Now, bearing in mind that our Sun is only a star, and if as far removed from us as are some of the other stars, would not at all be seen by the unassisted eye, we are better able to form some faint conception,

both of the distance and magnitude of this glorious body.

We have also seen that our Sun is a globe of liquid fire; that on its surface there are raging billows of molten matter leaping, and rolling, and tossing literally *mountains* high, while above and around this there is another ocean of gas in an incandescent state —that is, on fire, and producing intense heat, and dashing up and out in every direction its mighty tongues of flame one hundred thousand miles into the solar atmosphere. Besides all this, we saw there were other and even mightier forces operating there, projecting matter to the enormous height of one hundred and sixty thousand miles in an incredibly short time.

Now, as our Sun is comparatively a small body when placed by the side of such a vast globe as Sirius or Lyra, we may reasonably suppose that the forces operating on it are also comparatively feeble, and that incomparably mightier eruptions and physical agitations are constantly going on in these greater sun-worlds than are witnessed on our own.

If there are waves of liquid molten matter on our Sun heaving and rolling and tossing to the height of ten or twenty miles, we may suppose similar waves a hundred times higher, and rushing and rolling with a momentum and force a hundred times greater on these more ponderous orbs.

We are almost appalled at the thought of the action of such forces, and on such a stupendous scale. Think of an ocean of liquid fire, hundreds of thousands of miles in extent, without its headlands, capes, or promontories to break the force of its waves, and these waves rising to the height of one or two thousand miles, and rushing, and surging, and roaring as they

roll on unobstructed around that vast fiery world. And yet this is but a *single* world—one among millions of millions of equally grand and ponderous character—comparatively, an insignificant creature of the *Almighty Creator.*

If one is awed in the presence of one such world, with how much profounder awe should he stand before its all-powerful and every where present Creator!

DOUBLE AND TRIPLE STARS.

When we examine the heavens with a powerful telescope, we find that many of the stars that appear single to the eye alone are composed of two, three, four, or more stars. These are called Binary and Ternary systems, according to the number of which they are composed. By close observation they have revealed the startling fact that they *revolve around each other* in orbits of apparently small diameter. Another exceedingly interesting discovery in connection with them is the seeming slowness of the revolutions—requiring, as they do, from forty to sixteen hundred years to make one circuit. This proves, that though apparently so near, they are nevertheless at immense distances from each other. We must bear in mind here that these are *Suns* revolving around *Suns*, and not *planetary* systems like our world family and Sun. The revolution of these smaller suns around the larger establishes the most interesting fact that the law of gravitation—that is, the attraction of matter by matter—extends to the fixed stars. Before this discovery we had no actual *demonstration* of the truth of the theory that attraction operated beyond the limits of our own system or family of worlds, but when it was seen that one *Sun* revolves around another *Sun*, then it was clearly and satisfactorily demonstrated

that the law of gravitation is the law of the whole material universe; that we are all bound together to this mysterious force; that however distant might be anyone of those twinkling suns out in the abysses of space, yet it exerts an influence upon us, and our world, in turn, attracts that same remote star. Whatever else may yet be unsettled, this great truth is now well established.

Another most beautiful and interesting feature of these double and triple stars, is they often are of different colours. Thus we frequently find what to the unaided eye seemed to be single white stars, are, in reality,

BLUE, ORANGE, AND GREEN STARS,

seemingly *companions* to the larger stars around which they regularly revolve. Hence, the inhabitants of these systems—supposing them to be inhabited, as in all probability they are—those residents are probably somewhat differently constituted from us, as they have differently coloured light from their respective suns.

The cause of these different colours is revealed to us by the recent and most fascinating science of Spectrum Analysis. From this we learn that these various oolours result from the various substances in combustion in the gaseous flames enveloping those bodies; just as we often see here the flames from burning bodies are not always of the *same* colour, some giving blue, others red, and others green flames, &c. We must infer, therefore, that the substance is most abundant on any particular sun or star whose proper flame predominates. But the colour of a star is not always the same. Thus, Sirius is now decidedly white; but centuries ago, in the time of Ptolemy and

Seneca, they reported it as red. The change may be owing to the fact that the substance giving forth the red flame had been mostly consumed, and what produces a *white* flame is *now* the chief substance burning on that star.

NEW STARS.

Another interesting class is new stars. Suddenly, where all was blank space before, a star will all at once shine forth, and sometimes with more than ordinary splendour.

In 1572 one of these mysterious bodies suddenly appeared in the constellation Cassiopia in the northern sky. It was of such extraordinary brilliance as to be seen at noonday. It was supposed to be undergoing some extraordinary change from the most intense heat, as it exhibited all the phenomena of a great conflagration. It continued burning sixteen months, when it totally disappeared, and has not since been seen, though carefully watched for by numerous observers.

During the sixteen months it was seen it seemed to pass through all the changes of a great combustion. Thus, it was first a dazzling white, then a reddish yellow, and last of all an ashy pale. Its light was estimated at the time to be equal to the blaze of 1,200,000 worlds like our own, all collected into one mass, and all at the same moment wrapped in flames! What a conflagration would it be, the burning of our globe. But imagine one million two hundred thousand such worlds *all at one time* on fire, burning not merely trees and other substances easily consumed, but metals, rocks and earth, all melting away in the fierce heat as readily as the dry stubble of the field.

WHAT ARE THE STARS?

No. 3.

In our last article we closed with a brief reference to *New Stars*, stating that these have suddenly appeared in various parts of the heavens, and, in some instances, have wholly disappeared, leaving not the slightest trace of their former splendour.

But this sudden extinction is not true of them all. Stars that thus suddenly shone forth centuries ago, are *still shining to-day* with undiminished light, and, so far as we can see, are likely to so continue for centuries to come.

But the sudden disappearance of stars is not confined to those that have suddenly and recently presented themselves in the heavens. A few that were known to exist from the earliest recorded history of the stars, have also been, in a moment, as it were, blotted out of existence as refulgent Suns.

There is another class of heavenly bodies called

VARIABLE STARS.

While it is *generally* true that the stars shine with undiminished light, yet there are a few exceptions.

Thus, a Star in the neck of the Whale was observed in 1596 to undergo such changes that it was called Stella Mira, the "Wonderful Star." It would appear as a star of the second magnitude for about a

fortnight; then it would gradually diminish during three months, and at last become entirely invisible and thus remain for five months.

Then again it would appear just as a faint Star, and in about three months would regain its former brightness, and go through the same changes again. About 330 days are thus occupied in completing the whole series of mutations, although sometimes it would be invisible longer than five months, and did not always return to its former brilliancy.

But a more remarkable instance of change is observed in Algol of Perseus in the head of Medusa.

This Star ordinarily appears as one of the second magnitude, and so remains for about two days and fourteen hours.

Then its light rapidly diminishes, so that in three-and-a-half hours it appears only as a Star of the fourth magnitude. It remains thus reduced in brightness only about *fifteen minutes;* then increases its light so rapidly, that in about three hours and a half it regains its greatest brilliancy again. Thus the entire series of changes occupy only two days, twenty hours and forty-eight minutes.

Although these changes have been going on so many years, they are not yet satisfactorily explained. Some have regarded them as produced by the rapid revolutions of the Stars on their axes. This is, perhaps, as plausible as any theory; as our own Sun revolves regularly on his axis, and sometimes large dark spots are seen at regular intervals on his surface, which perceptibly diminish his light when carefully measured by the photometer, or light measurer. The stars being suns, doubtless revolve on their axes as does our own Sun.

As already intimated, sometimes the Star is *entirely*

extinguished, and never resumes *any* of its former brilliancy, but is wholly lost in the firmament.

In such a case we must remember that only the *light* of the star is extinguished; the body itself remains with undiminished *matter*, but exists no longer as a sun. It is thenceforth a huge, black globe, travelling through the dark abysses of fathomless space, *itself dark*, and no longer able to illumine its own path and make bright the paths of other worlds, but a great mass of blackness and darkness rushing on with frightful velocity into the darker depths around. We have reason to suppose that thousands of such huge, dark, invisible, monster worlds are to-day wildly careering through dark space, seemingly serving no purpose, yet doubtless fulfilling some grand design of their all-wise Creator.

CLUSTERS—"ISLAND UNIVERSES."

Another very interesting class of heavenly bodies is found in the Clusters of Stars. The number composing these is far greater than is generally supposed. Thus, in the Plelades, or Seven Stars, in which only six are seen with the unassisted eye, over two hundred are seen with a powerful telescope. Some of these clusters are globular in form, and their whole appearance indicates a central force; that is, the whole cluster revolves like a wheel on its axis, and seems to have some great attractive power in itself, and that power located near its centre. Hence it has been inferred that such a cluster constitutes in itself an immense system of systems on a most magnificent scale—a family of worlds apart from the rest, and governed by its own internal laws.

Dr Herschel remarks that "many of these globular clusters must contain upwards of twenty thousand

stars, compacted and wedged together in a space not exceeding the tenth part of the Moon." What an exhibition of Almighty power is this! Twenty thousand suns, each superior to our own, crowded into space so small that the tiniest infant's hand would more than twice cover it! And then, each sun surrounded by its planets; and these planets attended by their moons, or satellites; and yet notwithstanding their apparent proximity, each sun removed from its fellow sun at least ten hundred billions of miles, or as distant from each other as they all are from us! Of these "Island Universes," more than four thousand have been already discovered. "Verily, the heavens do declare the glory of God."

But when, aided with telescopic power, we direct our gaze to that mysterious zone or belt of light, the Galaxy or Milky Way, a new and greater wonder bursts upon our view; and as we turn that almost angel eye, the telescope, along that dazzling zone, we find eighteen millions of mighty suns so densely crowded together as to form a literal pavement of stars, and that pavement extending not only above our heads, but beneath our feet—even around the whole circuit of the heavens. And as we look with solemn awe upon that glorious scene, we almost think the angels' path has been unveiled, and man may see where seraphs tread. It will aid us to form a more correct estimate of the immense distance of those bodies, one from the other, notwithstanding their seeming nearness, when we remember that *our* Sun belongs to the Milky Way, and *our* Sun is a pebble in this wondrous pavement.

A GRAND DISCOVERY.

We come now to what is justly regarded as one of

the grandest discoveries of modern times. Hitherto we have regarded the Stars as *fixed* in space; and, to the common observer, they are so. Were our great progenitor to rise now out of his unknown grave, he would find the heavens wearing the same general aspect to-day as when he and Mother Eve looked with wondering awe upon their splendours, as they walked the grassy groves of Eden. Each Star would seem to his unscientific eye to occupy precisely the same place in the firmament. Nevertheless, there is a change, and it is now discovered that all the Stars are in motion. We have most striking evidence of this motion in the change of place of the Stars of the northern sky, in the constellation Hercules. These Stars are separating from each other, while those in the opposite part of the heavens are crowding closer together. A good illustration of this is furnished in what we see in passing through a forest, where the trees in advance seem to separate, while those from which we recede apparently come closer to each other. This proves most conclusively that our Sun is in motion through space toward the north, carrying with him our world and all the others belonging to our family.

Now if *our* Sun can be proven to be in motion, it is presumptive evidence of the motion of other Suns or Stars. But we have better proof of their motion, as we shall see. If there is motion, it must be in a curved line, for there is no *direct* motion—that is, in a *straight* line—in the universe. If the motion is in a *curved* line, it must be in a circle, and around some centre. That centre, it is thought, has been approximately found. In the Pleiades, or Seven Stars, there is one brighter than the rest, called Alcyone; and there, or in its vicinity, is supposed to be the centre

of our Starry system; not the centre of the *whole* universe—for that in mortal life will never be found—but the centre of all the Stars visible to us.

Maedler, a distinguished German astronomer, by a series of most profound and laborious investigations, found a large number of Stars having a motion which indicated this Star, Alcyone, as the sidereal centre.

Around this central Sun, then, our Sun, with all his plants and satellites, and all the other Suns visible to us, revolve. And do you inquire the rate of motion of our own Sun? Science answers, it is 33,350,000 miles each year. And do you ask the time required to complete one revolution? The astounding reply is, 18,200,000 years. What a mighty circle is that, that requires more than 18,000,000 of years to complete one circuit through it; and this, too, when the body is rushing on with an annual velocity of 33,350,000 miles. Thus, then, our Sun, and all the Stars of our firmament, are obedient to the attractive power of that far-distant mass; so distant, that its light, though travelling 182,000 miles each second, is more than five hundred years in reaching us. How mysterious, how far-reaching, how potent, that force we call gravitation, to control bodies at such inconceivable distances! Think here a moment! That far-distant mass, that central Sun, stretches out its invisible arms over the mighty abysses of space, and stretches them in all directions, and seizes each of these ponderous Suns, as if with Omnipotent grasp, and holds them all in their appointed spheres, as they rush on with almost lightning pace, and thus preserves order and harmony throughout the whole.

What a wondrous creature of the Creator is this force in nature we, in our ignorance, term Attraction.

As we contemplate its power in holding and controlling distant worlds, we are almost tempted to look upon it as something more than a mere *property* of matter, and to regard it as an intelligent agent, acting as Jehovah's vicegerent in the material universe.

But pause a moment longer before this wondrous spectacle. One hundred millions of mighty suns with their many hundred millions of planets and satellites moving in noiseless grandeur around their mightier centre, obedient to his silent but resistless influence. And what the magnitude of that central Sun, which by the laws of attraction must be far greater than the whole combined mass of these 100,000,000 of suns and their planetary worlds, in order to so attract all, as to hold them all in their respective orbits? The mind is overwhelmed at the thought of so much matter in one huge mass. One such world would seem enough for a universe.

But how complex the motions of these myriad worlds. Systems revolving around systems; suns revolving around suns; planets revolving around their centres; moons revolving around their planets, while 350 trillions of raging comets dash in all directions, their fiery trains streaming out millions of miles over empty space. And in all, neither sound nor voice is heard. O, how oppressively sublime is the silent march of the stars.

And is this the *whole* of creation? Are these the limits of Jehovah's Empire? No, no, no; for then would the finite have grasped the infinite, and the creature, approximately, have comprehended the Creator.

Take to yourself the wings of light, and fly to the most remote of these millions of suns, and, there, you would look out upon another universe of worlds. No

one of the familiar constellations of our sky would be seen. Fly then to the remotest Star visible from that new point of observation, and there again you would see in the depths beyond, another new firmament of stars; and then once more, with the wings of light, fly to the most distant of the suns of that newly unfolded creation, and from that point too, you would again see in the fathomless abysses beyond, new and most glorious displays of the creative power of the Almighty. And so, on the pinions of light, continue your flight through ten thousand years, and you would not then have reached the outskirts of creation. This stupendous system of one hundred millions of suns, and their attendant planets and satellites is probably but one of a vast number of systems of equal magnificence, revolving around some mighty centre, and this vast congregation of systems of systems may again be but one of a thousand more of equal grandeur, all circling around another and mightier central Sun; and these may again unite to form a still more immense system of systems, and in revolving around the great, unknown centre of all matter.

What an idea of the immensity of space does this give us. As we contemplate those mysterious bodies, which we in our simplicity call comets, as they come dashing down from heights immeasurable, or rushing up from depths unfathomable, with a velocity of ten hundred miles an hour, and then dash away again from us to traverse the regions of space at nearly the same speed through thousands of years, we wonder if it is possible that they can find room for their mighty wanderings; but our wonder may cease in view of the immense distances of these myriads of suns that faintly twinkle above, beneath, and around us.

WHAT ARE COMETS?

No. 1.

When those mysterious visitors from the vasty deep of limitless space suddenly appear in our sky, their trains streaming out millions of miles over the empty abyss, we are all startled, and eyes unused to look skyward are now turned to gaze upon the fiery-visaged strangers, and a new impulse is given to the study of astronomic science.

And here is, surely, a study worthy of us. Here is an exhibition more deserving of our attention than the most gorgeous spectacle man ever offered to his fellow man. Here is a new-comer invested with more *real* attractions, than Earth's mightiest monarch, coming with all the pageantry that wealth and art can produce.

Let us endeavour to learn more about this visitant from the far-distant homes of the stars.

Comets derive their name from the Greek word "Coma," meaning *hair*, from the hair-like appearance of the train. They have been divided into three classes: those having a nucleus, or head, those without a nucleus, but of uniform density throughout their whole mass, and lastly, those having trains accompanying the main body of the comet.

Those that have a nucleus or head are often of vast magnitude, but of extreme lightness, and have there-

fore, compared with their bulk, but a small quantity of matter. The nucleus is the brightest and most condensed part of these comets. Those of uniform density throughout have no nucleus, but appear as a great cloud of light of equal brightness in all its parts. By far the greater number have no trains; and those having trains are the only comets generally seen by the unaided eye, the others being too faintly luminous to be often seen without a telescope. Hence, the masses but seldom see a comet, and wrongly infer that there are only a few of these erratic strangers in existence, while, in fact, they are to be counted by millions.

They are proven most conclusively to be bodies of extreme lightness by the very small attractive power they possess, and the little disturbing influence they exert upon other bodies when they come near them.

Thus, for instance, when a Comet became entangled among the four Moons of Jupiter, they were not only left undisturbed in their old paths, but not in the least degree perceptibly affected; but, on the contrary, the Comet itself was so attracted by these comparatively small Moons, that it was thrown entirely out of its course. Hence, we must conclude that they contain but a very small quantity of matter. It is quite possible, and not at all improbable, that one of these moons of Jupiter so powerfully attracted this Comet that it drew it quite to itself, and immediately the Comet spread over the whole surface of that Moon; and it is there to-day as an atmosphere for that globe.

This is the more probable from the remarkable fact that the Comet, though diligently sought, has never been seen since its entanglement among these Moons. Indeed, it is possible that we ourselves, under Pro-

vidence, are indebted to some stray Comet of the remote past for our own atmosphere. It is possible that the air we now breathe, and which gently fans our fevered brows, and comes to us laden with so many rich and delicate perfumes from the flowers of spring —it is possible that this same air was once careering wildly through the vast abysses of space, a raging Comet, attracting the wondering gaze of the millions of inhabitants of other worlds. Of course, all this is only conjectural respecting the origin of atmospheres.

This matter, however, is often spread over an immense space, so that these same light Comets are bodies of enormous magnitude. As further proof of its extreme tenuity or thinness, the smallest stars are often seen through the train, and sometimes even through the nucleus or head also; while they are often distinctly visible throughout the *whole* mass of those of uniform density.

Dr Herschel has stated that the Comet of 1832—Bielas—passed over a clustre of stars of the sixteenth or seventeenth magnitude. Such stars are wholly invisible to the unaided eye, and require considerable telescopic power to bring them distinctly to view, and they are so easily obscured, that the slightest mist, say of the thickness of a few feet, would have shut them completely out of sight.

But the Comet just mentioned, had a thickness of at least *fifty thousand miles*, and yet through all this cometary matter those very small stars were distinctly seen. Now if 50,000 *miles* of cometary substance has not as much density as three or four *feet* of ordinary fog or mist, then we may be sure that the material of these gas comets is exceedingly thin and light.

But though the matter of these bodies is so at-

tenuated, or thin, yet from their vast bulk they must oontain a very considerable amount of substance of some kind. The comet of 1811 had a nucleus, or head of the diameter of 1,250,000 *miles*, and its bulk was nearly three times as great as that of onr Sun, and forty hundred thousand times as large as the Earth. Think of a gaseous ball spreading out 1,250,000 miles of such thinness and lightness that stars are distinctly seen throngh the most of it; and then add to it a train streaming out from one side to the enormous distance of 130,000,000 miles, and this magnificent body dashing through space at the rate of 1,000,000 miles an hour! To move with such rapidity, a body so vast and yet so light cannot meet with much resistance from any medium through which it passes; or, rather, it must pass through space without encountering *any* medium like our air, but must move through a vacuum, or what is nearly so—that is, space where there is no air. This is supposed to be the case; in other words, throughout the vast interstellar spaces—spaces between the Stars—there is no atmosphere, but perhaps, an exceedingly thin ether; and the friction with this attenuated ether is all the resistance encountered hy the comets and all other heavenly hodies, as they go rushing through their mighty orbits around their suns.

The comet of 1770 came within 1,400,000 miles of the Earth, and was of vast extent. It had a rare opportunity, therefore, from its proximity, to exert a powerful attraction on our globe. Had it contained matter equal to that of the Earth, it would have drawn our planet so much farther from the Sun that its orbit would have been sufficiently enlarged to have lengthened our year about three hours; because the circumference being so much increased, so much more

time would be necessary for our globe to complete its revolution through it. But no such lengthening of the year has been experienced. The work of the All Wise and Omnipotent Creator has been too well done to be thus easily disturbed.

This fact then, that the Earth was undisturbed by the near presence of this large cometary body, further proves that they are of extreme lightness. Indeed the clouds that float on our atmosphere are dense, weighty masses, compared with these comets.

THE IMMENSE TRAINS OF COMETS.

There is perhaps no part of these mysterious strangers that excites so much interest, and is really so wonderful, as the *trains* that often follow the head of the comet. And with all the investigations, with our improved astronomical instruments, and that multiplied observers enable us now to make, we are still perplexed respecting many features of these wondrous bodies. Still there is much satisfactorily proven.

That modern wonder of constructive genius, the spectroscope, has here rendered us more valuable service than even our largest telescopes. It has shown us that these erratic wanderers are undoubtedly of gaseous form, both nucleus, or head, and also the accompanying train. The largest telescopes have also been of invaluable service in examining the head of the body and its surrounding envelope, sometimes even in connection with it. These trains are now proven to be of the same material as the comet itself.

When first seen far out in the deep abyss, no train is visible, and probably *there* none exists.

But as it approaches the Sun, the train is rapidly developed until when it reaches its perihelion—that is its nearest approach to the Sun—the train is fully

formed and remains undiminished until it begins to recede from the solar centre, when it decreases as rapidly as it grew while approaching it. From this we are forced to the conclusion that the sun has great influence, if it is not the sole agency, in producing the train.

BUT HOW IS THE TRAIN PRODUCED?

We know that heat always generates electricity. Electricity has both attractive and repelling power. When two bodies are both charged with like electricities, that is of the same kind, then these two bodies similarly charged will *repel* each other. When they are charged with unlike electricities, they will attract.

Now it is very evident that in consequence of the enormous friction of the ceaselessly raging elements on one solar surface, there must be from this cause alone a vast amount of electric fluid generated, as friction also produces it; but when, in addition to this, we consider the inconceivably high temperature there fiercely raging also, we shall not find it difficult to believe that there must be accumulations of electric force of which we can have no conception, from any electrical phenomena of Earth.

Now this electricity, by induction, passes to other bodies vastly remote. We, doubtless, feel it here on our globe in various ways, producing electric currents over the entire surface of our planet, often affecting telegraphic apparatus, so as to hinder its operation. This has been conclusively demonstrated by these occurrences taking place in the absence of thunder storms, or any of the ordinary electrical phenomena.

Now this powerful electrical influence on the solar surface is very sensibly exerted upon approaching Comets as a *repelling* force, so that while the Sun's

great attractive power of *gravitation* draws the Comet to him, his *electrical* influence tends to drive the same body from him. But the *whole* body of the Comet cannot be thus driven off; and so a portion of the cometary matter, perhaps the lightest of it, is repelled by the electrical repulsion of the Sun, and thus the train is produced. But we see sometimes a projection similar to the train in *front* and at the *sides* of the Comet. This is probably produced by the electricity of the Comet itself; as the heat of the Sun must necessarily generate great quantities of the electric fluid upon its surface, and this drives off a portion of its more attenuated, or thinest matter, producing a hairy, or brush-like appearance in the front of the body and around the whole nucleus.

This subject is to be yet further investigated before we can reach perfectly satisfactory results; but with our enlarged instruments and new appliances, we may hope for much additional light at an early day.

The trains are generally turned from the Sun, although in some instances, they have been seen at right angles to the line of motion.

A very peculiar and interesting feature of the trains is that sometimes they are hollow cones; that is funnel-shaped. Some are also hollow cylinders, having nearly the same diameter throughout.

ENORMOUS LENGTH OF TRAINS.

This is, perhaps, the most striking feature of these mysterious gas-worlds. That matter should stream out to such immense lengths, and yet remain in actual connection with the Comet, is truly a marvel. But what is their length? And here, in answering, we deal not in mere conjecture; for these trains, by reason of their size and distinctness, are easily

measured. The Comet of 1680 had a train 100,000,000 miles in length. But this was surpassed hy that of 1811, which stretched out its train full 130,000,000 of miles. But even that was more than rivalled hy the overpowering splendours of the Comet of 1843. This truly wonderful body shot out its train to the startling distance of 200,000,000 of miles. It was of sufficient length to reach from the Earth to the Sun, and hack again from the Sun to Earth, and nearly twenty millions of miles over. It would have girded the Earth at the equator no less than 8,000 times. Now, we repeat, that matter so thin should yet remain in actual connection with the main hody of the Comet at the distance of two hundred millions of miles, is a wonderful fact; hut, when we remember that this same main body is dashing on in its path more than 1,000,000 miles each hour, and yet this same thin matter, thinner hy far than the thinnest mist, is nevertheless following on, and though at the enormous distance of 200,000,000 miles, still keeps pace with the nucleus, or head, itself, as it wheels with frightful velocity around the great Solar orh, to plunge once more into the fathomless ahysses of infinite space—when we remember all this we are confounded, we are overwhelmed in amazement, we are awed, as we stand in the presence of these tremendous forces of nature, operating on such a stupendous scale; and as we realize that they, with us, are the creatures of the same Omnipotent Creator, we are instinctively led to how with profounder reverence and more solemn awe before that infinitely more august Presence—the Almighty and common Maker of us all.

TRAINS RAPIDLY FORMED.

But the rapidity with which these trains are formed

is another startling phenomenon. The Comet of 1680 sent out in two days a train of 60,000,000 miles; while that of 1843 produced in less than twenty days its enormous train of 200,000,000 miles. What a spectacle is here! Matter 10,000,000 miles in length streaming out from that nucleus in a single day! And the wondrous work goes on until 200,000,000 miles are covered by this same mysterious train.

We have additional evidence that electricity is concerned in all this, from the fact that there are tremulous vibrations of light and slight changes of colour sometimes seen throughout the train, somewhat similar to what we see in the Aurora Borealis or Northern Lights, though these vibrations are not so marked as in these Boreal phenomena.

In addition to this, on the appearance of the great Comet of 1843, which had the largest train known to modern science, the magnetic needle was greatly agitated. Now we know that the polarity of the needle, that is, that property of it that causes it to point to the North, is owing to electrical currents circling around the Earth from West to East. When, therefore, the needle is disturbed by natural causes alone, and these causes are outside of the Earth's surface, or in the region of the atmosphere, we may be sure that electricity, in some way, is the disturbing influence.

As the needle was thus disturbed on the appearance of this Comet and its enormous train, it is still further proof that electricity was concerned in the production of this long appendage, and that throughout its whole wondrous length, it was pervaded by the same mysterious and subtle fluid; and that same subtle fluid had power to leap in an instant, as it were, across the mighty chasm between the Comet and the Earth, and make itself seen and felt all

over the surface of our own vast globe, and doubtless, on every other globe, belonging to our family of worlds. What a wonderful creature of the great Creator is this invisible fluid we call electricity? What power is seen in its creation? and what madness of folly to suppose that this agent having such amazing power in itself is a mere product of chance! What insanity to say that it produced itself, and thus ignore and deny the existence and power of the Great First Cause—Jehovah!

Let us be grateful to that All-Wise, and Almighty, and Merciful Being, that these seemingly lawless wanderers through space, are subject to Him and are guided by His Almighty Hand, that no harm has come to us from them in their mighty wanderings through His vast Universe.

WHAT ARE COMETS?

No. 2.

COMPOSITION OF THE TRAINS.

The material of which the trains are composed is essentially the same as that of the comet itself—that is, gaseous matter, but less dense. What kind of matter or gas it is we cannot always determine; hut on the passage of the comet of 1861, which came near to the Earth, some astronomers supposed that our glohe passed through its train, and the only effect was an appearance of a peculiar phosphorescent-like mist; in other words, at night there seemed to he a luminous suhstance faintly visible in the atmosphere, which passed away on the departure of the comet. As already remarked, the suhstance of the train is exceedingly attenuated or thin, as the faintest stars are generally seen through it.

RELATION OF COMETS AND METEORS.

There has been recently discovered a remarkahle connection hetween Comets and Meteors, or Shooting Stars. When a Comet has appeared, Meteors have been ohserved to be very much more frequent than they ordinarily are, and particularly along the path of the Comet; sometimes, indeed, falling in great showers, when they are numbered by millions. It has

been supposed from this that the cometic matter of the train has been partially attracted by the Earth, so that a considerable portion has been thus drawn off from the main body, and appears in our atmosphere as shooting stars.

If it be asked why these shooting stars are so often seen in the absence of Comets, we reply that it does not at all follow that there are no Comets near us because there are none seen. Large numbers pass unnoticed, because of their distance, their dimness and small size; while many more enter our heavens and depart unseen during the day and the moonlight nights, but leaving a portion of their matter in the remote regions of space; and this matter, after some time, finds its way to our globe, and is drawn into our atmosphere, and then ignited by the friction and oxygen of the air. Thus it will be understood why Meteors or shooting stars are seen when no Comets are visible.

NUMBER OF TRAINS.

Ordinarily, there is but a single train to a Comet, and more frequently, as already shown, none at all. But this single train does not always remain so, but often separates into two, three, or more trains. The train is often curved like a scimeter, or rather it has the graceful form of an ostrich feather. The comet of 1744 had a fan-shaped train divided into six distinct parts, presenting a most magnificent appearance, having beautiful, bright edges, while the middle was of fainter light. The great comet of 1825 had five separate trains, streaming out to an immense distance, and covering a large part of the heavens. The colours of these parts vary at times, producing a most striking effect. The cause of this separation of

the train into so many parts is not yet fully known, but it is supposed that electricity has much to do in producing this and many other cometary phenomena.

We have something strikingly similar in the Aurora Borealis, or Northern Lights. During the winter season, when the auroral displays are most striking and frequent, we often see the rays of light shooting up in separate columns and numerous spires, and suddenly vanishing, and then appearing again in other forms, and wider apart. Now, as already stated, electricity has a direct agency in producing these Northern Lights, and as these columns and spires bear so striking a resemblance, while they last, to the divided trains of Comets, we may at least suppose that these beautiful, fan-like trains are the results of the same general cause—that is, electrical agency.

COMETS NOT SELF-LUMINOUS.

The general opinion is, that the Comets shine by their own native light. This is a mistake, at least, so far as respects the large majority of Comets; if, indeed, it is not true of them all. But the question at once is forced upon us, if the Comets are not self-luminous, how is it that they emit so much light? In answer to this we have to say that they shine precisely as do the Moon and planets—by the reflected light of the Sun. This is clearly proven in that they exhibit the *phases* of the Moon—these phases changing as the Comet changes its position around the Sun; in the same manner as does the Moon in revolving around the Earth. But there is a difference in the *development* of these phases, owing to the fact, that while the Moon always moves in a fixed orbit around our globe, and invariably from

west to east, these Comets move in every conceivable direction—now coming from the east and going to the west; from the north and going to the south; from the south and going to the north; and then dashing down from the heights above, or rushing up from the depths beneath, and thus reaching the Sun from all points of the compass. Hence, from the variety of these motions, we cannot always expect the phases to occur in the same regular and established order as do the lunar changes. But the fact that these phases do occur—the Comet now presenting the crescent form; now the gibbous or bulging, and now appearing full or round—all these prove that these Comets have no power in themselves to give forth light, else they would always appear the same, as does the Sun.

MOTION OF COMETS.

The movements of these mysterious bodies have always been a subject of great interest, especially among astronomers. Unlike the planets, whose places we can always with comparatively little labour determine, these bodies are so erratic, that it requires far more laborious calculation to locate them at any given time.

At one time they seem about rushing into the Sun, so near are they to that body; at others they are so remote it would seem they must be forever beyond the reach of his attractive power, and never be brought back to feel his scorching heat. Thus the Comet of 1680 was within about 100,000 miles of the Sun, and then dashed away to the extremity of its orbit more than 70,000 millions of miles; that is more than twenty-eight times the distance of Neptune, the outermost planet of our family of worlds. This most

wondrous body came suddenly upon us, dashing down from the immeasurable heights, almost in a perpendicular line to the Sun, and on approaching it, swept around that body in an incredibly short time, with a velocity of *ten hundred thousand miles an hour!*

Sir Isaac Newton, after a careful calculation, estimated the heat it received from the sun when nearest it, to be *two thousand times hotter than red-hot iron!* It is exceedingly difficult to understand how a body can escape being wholly dissipated when exposed to such a frightful heat; and it but increases our perplexity respecting the character of these strange wanderers, to find them surviving an exposure to a temperature so fierce.

The Comet of 1843 wheeled around the Sun in two hours at the same startling velocity of 1,000,000 miles an hour. It almost grazed the Sun, and it was estimated that it was subjected to a temperature 47,000 times greater than the fiercest heat of the torrid zone. That anything visible should be left of a body after such an experience is truly a marvel, and a phenomenon like this must surely impress upon us more deeply than ever the declaration of the Sacred Oracles, "Great and marvellous are Thy works, Lord God Almighty."

The man who can contemplate the operation of these tremendous forces of nature, and on such a stupendous scale, and not be awed by an overwhelming sense of a Power infinitely superior to them all, is to be pitied as deficient in clearness of perception, and wanting in moral sensibility.

IMMENSE NUMBER OF COMETS.

The common opinion is, that as Comets are very rarely seen, therefore only a few are in existence.

But the reverse of this is true. Indeed, we hazard little in saying that they are the most numerous of all the heavenly hodies.

Arago, the eminent astronomer of France, has estimated the numher belonging to the Solar system —that is our family of worlds—as being more than 17,000,000, while Lamhert, another and perhaps equally eminent philosopher, makes the numher no less than 500,000,000.

Now what are the limits of the Solar system? The diameter of Neptune's orbit, the remotest planet from the Sun of our family, is 5,500,000,000 miles.

Within this circle of five-and-a-half hillions of miles diameter then, there are, according to these eminent scientists, from 17,000,000 to 500,000,000 of comets. We may reasonably suppose that other Solar Systems have each as many more, and the larger Suns a far greater numher. These estimates are hased upon the number of these hodies actually seen during a given time, and due allowance for those escaping our notice. But, the question here arises,

WHY ARE NO MORE COMETS SEEN?

This has heen already partially answered in the statement that many of these hodies come and go during the day and the moonlight nights, while large numhers escape our notice hy reason of their dimness and small size.

But there are others also that make but a single visit to our sphere, and are never seen by us again.

This brings us to notice the peculiar form of their orbits, or paths around the Sun. Those that are repeatedly seen by us, move in elliptical orbits—that is, oval-shaped—and therefore revolve around the Sun in various periods of time, according to their distance from that body.

But there are others whose paths are in curves called parabolic and hyperbolic. These curves are unlike the elliptical orbits which return into themselves, or are closed like a circle, whereas the parabolic and hyperbolic curves never return, but branch out into space, widening as they proceed like the lines of an angle. Now all the Comets that travel in such a curve, evidently, can only rush down upon us, or up to us, and dash rapidly around the Sun, and then leave our system forever.

Thus it will be seen that many of these transient visitors necessarily come and go without recognition by us.

THEIR IMMENSE PERIODS.

Some of these Comets which visit our skies, and after tarrying some time leave us and again return, are remarkable for their long periods—that is, the long intervals between these visits. These long intervals are owing to the immense journeys they perform in their very elliptical orbits; in other words, the very long ovals they describe in making their journey around the Sun. This will be better understood when it is remembered that one end of this ellipse, or oval, is near the Sun; in some instances only about 100,000 miles, while the other end is often many thousands of millions of miles distant, as already shown.

Some of the Comets have very short periods. Thus Encke's Comet—so named from the distinguished astronomer of Berlin, who first calculated its orbit—has a period of about $3\frac{1}{3}$ years, returning to us regularly after this interval. Thus it has been known to make its journeys, with great regularity, around the Sun for nearly three-quarters of a century. Others

have vastly longer periods. The Comet of 1844 has a period of 102,050 years—requiring this long time to complete *one* revolution around the Sun.

But the Comet of 1744 has the longest period yet known to astronomers. Such is the mighty ellipse described by this erratic body, that it requires one hundred and twenty-two thousand, six hundred and eighty-three (122,683) years to dash through its vast orbit, and make a single circuit around the Sun!

Of recent Comets the most striking was that of 1858, which many of our readers must remember, and which was first discovered by Donati of Florence; it has a period of about 2000 years.

COMETS EXPERIENCE EXTREMES OF HEAT AND COLD.

From approaching so near the Sun, a Comet must be intensely heated; and, as a result of this greatly expanded and converted into something very much thinner than the thinnest vapour known to us.

And on the other hand, from their receding so far into the depths of space, they must be exposed to a degree of cold far more intense than the lowest temperature of the Arctic regions of our globe. From this we must infer that they are greatly condensed by this intense cold, perhaps even to solidification; and then, on approaching the Sun again are once more converted by his great heat to a gaseous state. The mighty wanderings of these bodies aid us in getting a faint conception of space.

Think of a journey of 122,683 years, and the body one-half of this period going all the time nearly in *one direction* away from the Sun! And at last, having reached the extremity of its orbit, it yields to the attractive power of the great Solar orb, and obedient to his powerful rule, even at that remote point, begins its return journey of half 122,683 years.

What a striking illustration does this again give us of the wonderful power of gravitation or attraction. That mysterious body, the Sun, has exerted a repelling, as well as attracting force upon this cometary body; and now while far out in the dark abysses of space that repelling influence declines, so that the fugitive is arrested in its farther flight by the attractive power of the great luminary, a power felt even there by that lonely wanderer in those great, silent solitudes of everlasting space. How wonderful the power of this mere property of matter—attraction.

That Comet in its rapid flight, dashing on through the great profound, seemingly, a lawless vagabond of the skies, apparently subject to no law, is, nevertheless, every moment of that flight, feeling the strong grasp of its great controller standing majestically and blazing gloriously at the centre of his great system; and at last, this vagrant of the skies acknowledges its allegiance by turning back to its material lord, nor tarries in all the way, until it has done its customary obeisance in his burning presence! Verily, great is the power of gravitation. And how great is He who, by a word, gave to *every atom of matter in the whole universe of worlds*, this same mysterious power, this amazing force of attraction; so that *every individual atom* of matter can reach out over and across the mighty unfathomable depths of space, and can there exert a silent, but irresistible influence upon mighty Suns and mightier systems of great Sun-worlds!

And now, *every atom* of *matter* in the *great universe*, *completely fulfils* its mission in attracting every other atom, with *all* the *power given it;* and *every atom* of *matter* in the *universe* is obedient, and yields itself *unresistingly* to the attractive power of every other atom, and thus obeys the great Creator of all.

WHAT ARE COMETS?

No. 3.

In our last article we considered the motions of Comets, and saw that at times they dashed through space with the amazing velocity of ten hundred thousand miles an hour. It must not be supposed, however, that this rapid motion is the same throughout the whole extent of their orbits. Owing to the diminished attractive power of the Sun as they recede into the depths of space, their motion is not uniform. This attractive power of the Sun decreases by a fixed law; for example: As the square of the distance increases the attractive power decreases. This is true of all other bodies as well as of the Sun. To illustrate: Take the square of 4,000 miles. This is 16,000. Again: Take the square of 8,000 miles. This is 64,000. Now, if the attraction of the Sun upon a body 4,000 miles distant is represented by 100, this attraction upon another like body 8,000 miles distant will be represented by 25. The *distance* is only *twice* as great, but the attractive power is only one-fourth, because the universal law is, that attraction decreases as the square of the distance increases. Hence, *all* the heavenly bodies move slower in proportion to their distance from the Sun according to this law.

The Comet of 1680, when at its perihelion—that is, the point of its orbit nearest the Sun—moved 1,000 000 miles per hour; hut when at its aphelion—the point of its orhit farthest from the Sun—it moved only ahout six miles in the same time. But as the Comet passes its aphelion and advances again toward the Sun, its velocity rapidly increases with each mile of advance, because the Sun's attraction is increased in the ratio given ahove.

There is another cause of retarded motion. There is supposed to he a thin, filmy fluid pervading all space, which, hy its resistance to bodies, and consequent friction, lessens their velocity; just as the air resists and retards the motion of moving bodies. A very remarkable fact in connection with Encke's Comet is explained hy referring it to this cause. This body has now heen known for nearly a century, and during its successive revolutions around the Sun, once in ahout every 40 months, it has been found to complete these revolutions each time two-and-a-half hours too soon, according to the calculations of astronomers; in other words, the Comet was two-and-a-half hours in advance of predicted time.

This is explained upon the supposition that as the projectile force of the Comet—the force that carries it forward--is diminished hy the resistance of this ethereal fluid pervading space, the Solar attraction has less force to oppose, and so is constantly drawing the hody nearer to itself as its shortening periods most clearly prove. The Comet thus makes each revolution in a *smaller* circle than it made the last.

The result very obviously must he, if this approach to the Sun continue, that the body will fall, at last, into the Sun and be consumed.

This *may* be the fate of all the Comets, and even

of all the planets, if it can be proven that they too are thus revolving in constantly shortening periods and smaller circles. But this has not yet been done; nor is it probable that it will be for centuries to come. To prevent perplexity here, it must be borne in mind that the Sun has *two* forces which are constantly being exerted upon all matter within the immediate sphere of his influence; first, his *attractive* power, generally termed the force of gravitation, by which all matter constantly attracts matter; second, his *repelling* force, by which the same matter is more or less repelled. Now it is not yet *fully* known what this repelling power is, or how it is exerted; but, as we well know, that electricity produces the same repelling effect upon bodies on our globe, both gaseous and solid, and as we also know that electricity is inconceivably more abundant on the Sun than on the Earth, it has therefore been thought by many that the wonderful repelling power which the Sun evidently has, is owing to the vast amount of electricity upon his surface.

Furthermore, in consequence of the constant operation of this force, some bodies are drawn actually into the Sun and consumed, while others are seemingly more influenced by his repulsion than by his attraction and are driven off. This will explain why some large solid bodies dash with such violence into the Solar orb, while the trains of Comets and some of the Comets themselves are often repelled. This repelling power is known to be exerted at a great distance from the Sun, as is proven by the immense length of the trains of some of the Comets. Thus the Comet of 1843, as already shown, had a train 200,000,000 miles in length—long enough to reach from the Sun to the Earth, and back again from Earth to Sun, and

nearly 20,000,000 miles over. Now this repelling force was felt to the remotest point of that immense train, else the matter would not have extended so far, nor remained there so long.

It may yet be discovered that this repelling influence of the Sun has more to do in keeping our globe and other worlds at their respective distances from him than has been supposed; and that it is not *altogether* owing to the *centrifugal* force—that is, a force flying from the centre—that we are constantly kept so far from him.

Among the millions of Comets constantly dashing through the solar system, and others visible to us, only about 600 have been subjected to scientific observation. The orbits of about 200 of these have been approximately ascertained. The labour involved in the calculation and making out of a Comet's path is immense, and therefore comparatively few have been sufficiently studied to determine accurately their orbits.

ORIGIN OF COMETS.

We come now to an exceedingly interesting and difficult subject, one that has long occupied the attention of the mightiest intellects of Earth. We have seen that the composition of these bodies is chiefly, if not wholly, gaseous; that they are of extreme levity, so light indeed that we know of no substance on our globe with which to compare them; that, notwithstanding their lightness, they move far more rapidly than any of the heavier bodies of the universe, as the great planets and their satellites or moons—just the opposite of what we, with our notions of falling bodies, would expect. As we find so much that is mysterious in their character, we are better

prepared to expect some mystery respecting their origin.

There are two theories offered in explanation of the origin of Comets: the first represents matter as thinly diffused through space and as motionless, until the Almighty fiat went forth that all matter should be impressed with the property of attraction: that instantly there was motion among *all* the particles of matter throughout the *whole* material universe: that there were various centres of aggregation where these particles centred more or less, forming bodies of various degrees of density, and some of these being but slightly condensed, have thus far remained Comets of different magnitudes and degrees of condensation. This is, in brief, a statement of what is called the nebular hypothesis.

But there is another and more recent theory, which by many is received with more favour, and which in the light of recent discoveries of solar phenomena, is more satisfactory. This theory assumes that Comets are the product of the Sun by expulsion—in other words, that these bodies have been expelled from the interior of the Sun by volcanic force, and expelled with such violence that they were thrown so far as to be beyond the sphere of his superior attraction, and were drawn away by the atttractive power of other suns, aided by that other peculiar and mysterious force of the solar orb—his wonderful *repelling* power, which probably had more influence in driving these newly formed cometary bodies off into the depths of space than the attraction of other systems of worlds.

But most of the Comets known to us must have had a far more remote birth-place than the Sun. As the Stars are also Suns, and of similar constitution with our own, we may justly infer that they too are expel-

ling masses of matter, which escape into space and become the seemingly lawless wanderers we are considering.

But let us see if there is just ground for this theory of solar expulsion. With the aid of modern telescopes we are able to see many phenomena on the surface of the Sun before unknown. Thus, as before stated, we now know that there are convulsions on that body of the most violent character—convulsions compared with which all the tornadoes, tempests, earthquakes, and volcanic eruptions of earth are but as the rippling waves of some embowered pool stirred on a summer eve by the gentle zephyrs of the south. These tremendous forces operate not only on the *surface*, but in the *interior* of that vast globe, upheaving the molten mass, and projecting into and beyond the solar atmosphere vast masses of matter, gaseous, liquid and solid, some of which rise to the astounding height of 160,000 and even 200,000 miles. This is not mere conjecture. The astronomers of to-day are accustomed to watch with their superior instruments these mighty convulsions, and can easily measure with accuracy the effects of these eruptive forces. After careful investigation, the conclusion is reached that there are forces *now* in operation upon the solar globe, forces sufficiently powerful to project matter out into space so far, that it will not return to the Sun, but continue to move through space in the direction of the nearest and most powerful centre of attraction—that is, in the direction of the nearest largest world.

We repeat, it must be borne in mind in connection with this subject, that there are *two* forces ever operating on the Sun to produce these results—the *projectile* or volcanic force, and the *repelling* or *electric*

force. Probably, neither alone would be sufficient to produce all these wonderful results.

What has been said of the Sun as a source or birth-place of Comets, will apply, as already remarked, to the fixed stars, inasmuch as they are bodies essentially like our solar centre. We may infer, then, that they too are engaged in the work of comet-making, and some of them, doubtless, on a vastly larger scale than our own Sun, as by their greater magnitude they are capable of exerting correspondingly greater expulsive and repelling force. Their Comets, it is thought, have visited us, and it is a question of no little interest, How long have they been in making the journey? This question has engaged the attention of some of the mightiest intellects in the scientific world; and the answer given is, it will require 8,000,000 years for a Comet from the *nearest* star to make this friendly call. The long periods of some of the Comets seem to fully justify the assertion that some of them come from the stars. Thus, for instance, we have seen that the period of one was 100,000 years, and that of another over 122,000 years. Now, as we go from the Sun to the outskirts of our family of worlds, we find no source *within* our system whence these wondrous bodies could come. We are therefore compelled to go *outside* of our family of worlds to find some place where Comets can originate. But where can we go? After leaving our own family circle, we find, as we wing our way out over abyssmal space, that all is emptiness and utter desolation. Occasionally a meteor or aerolite may dash by; a Comet, hastening on to its far-distant solar centre, may sometimes cross our aerial path; but save these, all is one vast, dark profound, where neither sound nor voice is ever heard. And thus we dash on on the pinions of light, measuring the mighty

void at the rate of 182,000 miles *each second* of time; thus we dash on twelve months with the same lightning speed, and still no possible birth-place of Comets appears. *Twice* twelve months we dash on at the same lightning speed, but still no mother sun-world lights up our dreary path.

Thrice twelve months we dash on, with no abatement of the frightful velocity, and not yet even do we find a single source when might a Comet spring.

More than three years must we, with the speed of the morning light, press our way out into and over the abysses of space, before we can find a world that has Comet-producing capacity, and that world is the nearest Star. Now, as we find no worlds between our system and the Stars, nor any source whatever whence a Comet might proceed, we are led to believe that many of these vagrant bodies spring from the Stars as from our Sun, being first *expelled* by *volcanic* action, and then *repelled* by *electrical* force, and thus sent out on their long, mysterious, and to us seemingly useless journey through the untenanted regions of the universe.

ARE WE IN DANGER FROM THE COMETS?

In former ages Comets were sources of great terror to the ignorant masses, and were regarded as the forerunners of great calamities. Among savage tribes, particularly, they still produce intense excitement, and are looked upon as the precursors of famine, pestilence, and wasting war. They sometimes call them "the spirits of the Stars," and employ various means to prevent the evil they are supposed always to bring — wildly and violently gesticulating toward the unwelcome visitor with fierce threats and fiercer expression of countenance,

while they shoot arrows and dart javelines, and hurl huge stones at the much-dreaded Comet, hoping thus to avert the threatened danger. Nor have wild savages been alone in these fears and foolish demonstrations against these fiery-visaged strangers. In all ages, even among the civilized, there have been frequent manifestations of gross ignorance and superstition on their appearance. The Comet of 1456 developed the superstition and ignorance of the highest classes of some countries, in a remarkable degree. The body was truly of imposing aspect, having an immense train of the form of a sabre, and sweeping over the third part of the heavens. At this time the Turks were threatening to overrun Europe, and had just captured Constantinople; and the huge sword-like train hung like a frightful menace in the heavens, and seemed to be an awful warning written in letters of fire on the midnight sky. The Pope, Calixtus II, shared in the general terror of people, priests, and cardinals, and, therefore, after having, with all the solemnities of the Church, duly anathematized and excommunicated the Comet, he framed this new prayer to be used in all the churches: "Lord save us from the devil, the Turk, and the Comet."

By this time the Comet had passed its perihelion —place nearest the Sun—and had begun to recede, and was soon out of sight, and then a great victory over the Comet was claimed for the powerful Pope!

But is there any real danger to be apprehended from a Comet? So far as respects a collision with these bodies, we certainly have but little to apprehend.

In 1832 a Comet, as predicted, passed within 20,000 miles of the Earth's orbit, or path. Great anxiety was manifested lest by such close proximity some injurious effect might be produced upon our atmos-

phere, if nothing else should happen. Now the Comet came, true to the appointed time, and did then actually, as foretold, cross the Earth's path; but, providentially—and was it not a providence?—our globle did not reach that point until a *month later*, and then the much-dreaded Comet was many millions of miles distant, quietly pursuing his long journey around the Sun.

This was the wonderful body that, as it approached the Sun, separated, dividing into two parts, and these two pursued their respective journeys in the same direction until lost to sight.

There are hardly any phenomena that so make us feel the necessity of a gracious, superintending Providence as the movements of these apparently lawless wanderers of the skies. The planets, as said, all move in *one* direction around the Sun, and in fixed orbits; but these vagrant bodies move in *all* directions, and hence we are far more in danger from them than from any other of the heavenly bodies. But, as yet, our world, so far as we know, has never suffered from their presence. Does not this indicate that we are mercifully watched over by a beneficent Creator, and that each of these wanderers is guided by the same Almighty Hand that gave them existence?

THE CHANCES OF COLLISION

have been very carefully calculated by some of the ablest astronomers of modern times.

Such was the terror excited in Paris among the populace by the Comet of 1773, that some persons of weak minds and highly nervous temperament actually died from fright in consequence of a prediction that the Comet would dash against and destroy the Earth. To allay the excitement, the government requested

the French Academy of Science to investigate the subject of possible collisions between our globe and these sky-wanderers; and Arago, the great French Astronomer, reported that of 281,000,000 of chances, there was only *one* single chance for a collision. Hence the probability of such collision is very slight.

But should a collision occur with a gaseous body of this class, it could not, owing to its extreme lightness, reach the *surface* of our globe, but would be arrested by the atmosphere, and float in or upon it, as do the clouds. If the Comet were composed of noxious gases, then it might do us serious evil by poisoning our atmosphere and rendering it unfit for respiration.

Or, should the gas be of an inflammable nature like hydrogen, then by reason of the oxygen in our air, the whole atmosphere would be rendered explosive, and direful consequences must inevitably result. Were a hydrogen Comet of sufficient size to envelope the entire globe, and so mingle with our atmosphere as to make the whole an explosive compound, then the lighting of a *single* match would ignite the whole compound of gas and air, and in an instant produce such a flame as Earth never saw; a flame that would in an instant destroy every living thing on the face of the Earth; and in an instant deluge the *entire* surface of the planet by the mighty waters produced from this same fierce and terrible flame. (We must barely mention here that in burning hydrogen gas in oxygen, water is the result, as water is composed of these two gases.)

But while all this is rigorously *possible*, it is not at all probable that it will occur for many thousands, perhaps millions of years.

Nevertheless, a removal from among these Comets and Planets to a purely *spirit*-world must soon come

to us all. A world where we shall forever have done with *matter* in all its forms; where we shall be *outside* of the whole *material* universe, where *we, ourselves*, shall be *all spirit;* hands, feet, head, heart, all gone, and yet in full life, nay, with inconceivably more life, but without *one atom* of *material* substance clinging to us, and thus to be for all eternity. This removal, and this wondrous and now incomprehensible change, most surely awaits us all, and *must* inevitably be *soon* experienced by all. Happy they who are prepared for it! Happy they who with a loving, trusting, and obedient heart can sincerely say: "I know that my Redeemer liveth," and "because He lives I, by faith in Him, shall live also."

WHAT ARE SHOOTING STARS?

From remotest antiquity there have been seen darting across the cloudless sky what seemed to be Stars, differing from the Stars, however, in that they soon disappeared, leaving only for a few moments feathery lines of light along their paths. They have been compared to "fiery arrows shot from some invisible bow in space," but aimed at no definite mark.

There is a peculiar fascination in their appearance, and they always awaken a lively interest both among the learned and the ignorant, and a desire to know more of their character and origin.

These bodies are known to the masses under the common names Shooting Stars, Falling Stars, Fireballs, and Thunderbolts. Among the scientific they are classified as Meteors, Meteorites, Aerolites, Eolides, and Uranolites. They are regarded as having essentially a common origin, and bearing generally a striking resemblance to each other. It is hardly necessary to say that they are not Stars, nor do they bear any resemblance to them in their constitution or motions.

We began with the class known as Meteors, the least important but most numerous of them all. These are evidently composed of some very light and combustible substance, as they take fire and are con-

sumed in the air, and therefore never reach the surface of the Earth. From the brilliancy of their light, and the fact that they ignite at very high altitudes where the air is very thin, we would infer that their substance was of a phosphorescent nature, and easily set on fire at a very low temperature.

HOW THEY ARE SET ON FIRE.

The question will at once arise "how those bodies can take fire away from all heat and flame, and even in the highest regions of the atmosphere, where the cold is so very intense."

We all know the effect of friction in producing heat. If we take a small coin and rub it quickly a few seconds on a smooth board, it will soon be of a temperature to burn the hand. Now, one of these bodies in passing through the atmosphere has a somewhat similiar experience. By its rapid motion it compresses the air before it, and thus greatly increases its density, making it more difficult to pass through. But it does pass through, and with immense velocity, and this produces so much friction that sufficient heat is produced to set the body on fire, and thus it continues until there is nothing more to burn, and then the Meteor, of course, disappears. The temperature of the compressed air is probably raised, and this aids in igniting the Meteor.

The production of heat by compressing the atmosphere is strikingly illustrated by a simple experiment. Thus, if a tightly-fitting piston, having a little tinder or punk attached to the end of it, be suddenly forced into a cylinder, the air in the cylinder will be so compressed that sufficient heat will be evolved to set the tinder on fire.

These bodies are frequently seen moving in a hori-

zontal direction for a short distance, and then disappearing.

In such cases, they are at a great elevation, and are seen but a short time as they merely pass through the *outer* part of the Earth's great atmospheric envelope, and can be visible only while immersed in it; because beyond the atmosphere, there is nothing sufficiently dense to produce the friction requisite to evolve heat so as to emit light.

Their motion is generally toward the Earth in an oblique direction, although occasionally, from some unknown cause, they have been seen to dart upward.

Although their motion is toward the Earth, this class of bodies never reach it, nor do they come very near it. This is conclusively proven by the fact that they are never seen during a cloudy sky. It will be at once seen that they do not approach very near the Earth's surface, when we remember that the clouds vary in height from about one-fifth of a mile to five miles.

Now as Meteors are never seen *beneath* the clouds, it is evident that they never approach near the surface, but are entirely consumed in the atmosphere some distance above the Earth.

There is another class of bodies similar to these, which are seen *under* the clouds, and are also known to fall to the Earth. These we will consider hereafter. The altitude of visible Meteors varies from 6 miles to 140. Their velocity is estimated to be from 1,000 to 2,000 miles per minute.

With this class of bodies there is no explosion nor audible report, but they move silently through space. Probably, however, were we sufficiently near, we should hear a sound as of a swiftly rushing mass, for we can hardly conceive of a body, even though

gaseous, moving at the rate of one or two thousand miles a minute, and yet thus moving without any perceptible noise.

OF VARIOUS MAGNITUDES—THEIR ORIGIN.

Some of these peculiar bodies are quite small, probably not more than a few feet in diameter, as they are so soon consumed; but others are unquestionably of great size. One was seen as large as the rising Moon, and remained visible for some time. If it was 110 miles distant, as it probably was, then it must have been fully 1 mile in diameter. But if only 1 mile distant, then it must have had at least a diameter of 48 feet.

It was formerly supposed that they originated in exhalations from the Earth. This theory probably had its origin in the well known fact that some gases are formed on the Earth's surface, and ignited by the oxygen of the air. Thus the common phenomenon called the Jack o' Lantern is produced by the formation of phosphorous acid from decaying bones in low, swampy ground, and from hydrogen gas rising in the vicinity from decaying leaves at the bottom of stagnant water. This may be easily proven by gently stirring the leaves, when the gas will rise in bubbles to the surface, and may be collected in an inverted tumbler, the air being first expelled from the glass by filling it with water, when the gas bubbles may be caught, and will displace the water as they rise in the vessel. A lighted match applied will be followed by a slight explosion, and prove the success of the experiment. Now, these two gases, phosphorous acid and hydrogen, unite in what is chemically termed the *nascent* state, that is, at the moment of their production, and when united, the compound is called phos-

phoretted hydrogen, which is so very inflammable that it is actually set on fire by the oxygen of the air, and burns slowly as it gradually moves with the air-current, until entirely consumed. This, the Jack o' Lantern, it was once supposed, explained the origin of Shooting Stars. It is sufficient to say, that the production of phosphoretted hydrogen on the Earth's surface, is entirely inadequate to furnish the splendid meteoric displays so often seen ; and, moreover, even if sufficient, it would be all consumed near the surface before rising to such heights as we so often witness these beautiful phenomena—consumed just as is the Jack o' Lantern itself. Hence we see that these bodies cannot originate on our globe, and we are compelled to look elsewhere for their source. What is that source?

Astronomers are now very generally agreed that Meteors are, as before stated, immediately connected with Comets. It has been often observed that when Comets visit us, Meteors are most frequent, and they continue to dart in large numbers across the sky, even long after the Comet has departed.

This is particularly true of those Comets that approach near the earth. In such cases, the trains sometimes almost touch the upper regions of our atmosphere, and seem to leave a portion of them behind, this portion of the train being drawn to us by the superior attraction of our planet, and reaching soon the dense part of the upper air, they are ignited, and thus we are made aware of their presence. Their motion, however, is too rapid to refer it to the Earth's attraction alone. Some other unknown force must propel them in their wondrous flight.

Occasionally we see immense numbers of Meteors in a single night ; sometimes appearing to fall almost

as thickly as the snow-flakes of a midwinter storm. This was the case in the

GREAT SHOWER OF METEORS OF NOVEMBER 13, 1833.

This most wonderful phenomenon the writer had the good fortune to witness, and the impression then made can never be effaced. The heavens probably never offered, and Earth surely never beheld a spectacle so sublime. From all parts of the sky there was one continuous rain of seeming stars; and doubtless, to the ignorant, who regarded the falling bodies as veritable Stars, it must have been a matter of wonderment that a single twinkling orb was left to adorn the heavens on the succeeding night. But that succeeding night they were all still there. Not one Star was missing, and to the amazement of the multitude, the heavens wore precisely the same old aspect as before During the falling of this fiery rain, nearly every fire-drop would leave a luminous, feathery streak along its path, which would remain a few seconds, or minutes, and then wholly disappear.

Occasionally a larger body would dash with startling rapidity across the heavens and leave a much longer, broader, and brighter line of light, which would remain for an hour and assume peculiar forms that were supposed to resemble various objects, according as the beholder was under the influence of fear, superstition, or imagination. Thus some saw in these fantastic lines, swords, spears, and huge serpents, while some confidently asserted that the word WAR was plainly seen in letters of fire on the dark sky. A pruning hook was, however, distinctly seen in the north-east, which continued visible a full hour-and-a-quarter. It added not a little to the impressiveness of the scene that the most perfect still-

ness reigned throughout the whole visible heavens, inspiring a feeling of awe in every beholder. Some persons actually died from terror, supposing the heavens and the earth were on fire, and that the day of final judgment had verily come. It will here he horne in mind that the falling of Stars is spoken of in connection with the last day in Scripture, and, as already remarked, the falling hodies had every appearance of Stars, with the additional lines of light trailing after, which tended to make the spectacle still more grand and awful. Hence the terror of those entertaining such views. This amazing exhibition extended over the whole of the United States, from the lakes of Canada to the West Indies, and from about longitude 61 deg. in the Atlantic to 100 deg. in the heart of Mexico. The shower hegan hefore midnight and continued nearly seven hours, and but for the sunlight, douhtless would have been seen much longer. The same exhibition was seen on the following night, but in other parts of the world, and on a less grand scale. For three or four years after, the meteoric showers occurred ahout the same time in Novemher, hut the Meteors were far less numerous and not so hrilliant as at the first display in 1833. Somewhat similar phenomena have occurred ahout the 12th of November, 1799, in South America, at Cumana. So also in November, 1831, another shower was witnessed in Ohio and in Spain, but hoth inferior in splendour to that of 1833. Other showers of like character have occurred at various periods all more or less remarkahle for the numher and hrilliance of the Meteors. Those of November proceeded from a point in the heavens near the star Gamma, of the constellation Leo. This point was evidently very distant from the earth, as

it remained fixed among the Stars, and like them apparently moved westward. This proves that the source of these mysterious visitors was not within the limits of our atmosphere, else it would have revolved with the atmosphere from west to east, whereas its course was in the opposite direction from east to west.

A very singular fact was noticed in connection with this radiating point. It did not itself seem luminous; at least, it gave to us no light. There was a dark, circular space of several degrees diameter—a degree on the sky being about twelve inches—and from this the Meteors all seemed to come, and though not always seen to start from it, yet their lines of light all pointed to it. From this it would seem that this meteoric source was a huge globe of gaseous or phosphorescent matter, and that in its march through space it came so near our globe that its superior attraction drew separate portions of its substance into our atmosphere, which set them on fire. The colours of some of these bodies were most beautiful, and a few exhibited all the hues of the rainbow, appearing like broad ribbons, the tinted stripes most delicately blending as they streamed across the sky.

Occasionally explosions were witnessed, which must have been at great elevations, as they were seen over a wide extent of country, and though evidently very violent, yet no sound was heard.

These phenomena we may expect to occur periodically, with more or less brilliancy.

The time most likely for them to appear is about the 12th and 13th of November, and also about the middle of August; but they are often seen at other times, and especially within the tropics.

On the 18th of May 1838, an exceedingly splendid Meteor passed over the northern part of the United

States and Canada. Its diameter was estimated by Professor Loomis to be three-quarters of a mile. He also stated its velocity to be 2100 miles per minute, and it was only about thirty miles above the Earth.

UTILITY OF COMETS AND METEORS.

It has already been suggested in a former article that Comets probably furnish a portion of the fuel which aids in sustaining the heat of the Sun, as some of them after revolving around him for thousands of years are at last drawn to his surface by his superior attraction overcoming his repelling force. The same may be true of Meteors which doubtless fall into the solar atmosphere far more frequently than into the Earth's, owing to his greater power of attraction. They may possibly also have some beneficial influence upon our atmosphere in supplying it with some necessary gaseous elements which are consumed or absorbed in the support of animal and vegetable life.

It is not improbable, too, that they are designed to accomplish a *moral* purpose by giving us some intimations of the boundless resources of the great Creator, and teach us some lessons respecting the early condition of our own and other worlds.

We learn also from these bodies that mere gas-worlds do *now* exist, and we know from the teachings of Chemistry that these gases can be condensed even to solidification, and hence we may infer that such was once the condition of our own globe—*i.e.*, gaseous. But of this we shall speak more fully hereafter in other articles.

WHAT ARE AEROLITES, OR AIR-STONES?

In our last article we endeavoured to answer the question, "What Are Shooting Stars?" This article is a continuation of the answer. We then showed that one class of these bodies were *Meteors*; we now present another class called Aerolites, or Air-Stones, because they fall from the upper regions of the atmosphere; and these are of a far more interesting character. Aerolites are the fragments of Meteorites. They derive their name from the Greek words *aer*, atmosphere, and *lithos*, stone; hence, *Aerolites*. In appearance they are very much the same as Meteors, save that they frequently explode, sending out most beautiful coruscations and sparks like an immense rocket.

These explosions are frequently heard with great distinctness, and are generally followed by a whizzing sound as of bodies falling through the air. The *Meteorite* generally passes on its course after these explosions, and is soon outside of our atmosphere, and ere long entirely disappears. The *Aerolites*, however, always fall to the Earth, as do also, occasionally, Meteorites of the smaller class. The explosion is doubtless caused by the mass being unequally heated throughout, thus producing unequal

expansion, causing fragments to fly off from the outside of the body, and often rending asunder the whole mass, in which latter case the whole body will fall to the Earth if the fragments be small. The heat, as before stated, is the result of friction of the atmosphere, which would necessarily raise to a high temperature the outside of the body, while the *interior* would be hardly warmed, owing to the heat-conducting property of the mineral matter being so light.

This is well illustrated by throwing large stones into a hot fire, when explosions and reports will follow for the same reason—unequal temperatures throughout the mass—the outside being greatly heated, while the inside is not. Should any of our readers be disposed to try this simple but very instructive experiment, we would suggest that they keep at a respectable distance from the aforesaid stones, as unpleasant experiences might otherwise result.

FORM AND COMPOSITION OF AIR-STONES.

The shape of these mysterious bodies is generally that of an irregular pyramid, though often of other forms. They are also strikingly similar in respect to their surface, having a black, glossy aspect, as if they had been covered with some pitchy substance.

They are often so much alike in their colour, density and general structure, that we are almost forced to conclude that they are the scattered fragments of some one mass rent asunder by unequal expansion and contraction of different parts of the body.

They are composed of about twenty elementary substances—that is, *simple* substances. Our globe is made up of sixty such elements; but in all the Aerolites that have been found, only one-third of these earthly substances have been discovered. But it must

not be supposed that all these twenty substances are found in a single Air-Stone. Sometimes they contain but two or three, as iron, nickel, and chromium; others are almost pure iron; others have a small quantity of copper, while others have sulphur, and cobalt, and manganese.

They are chiefly of a *metallic* character. The stony Aerolites are mostly composed of silica—i.e., sand—and the metallic oxides, or rusts. The substances that predominate in these strange visitors from other worlds are magnesium, chromium, nickel, iron sulphur, and silex—that is, glass. None of the *precious* metals are known to exist in them. It is a very remarkable fact that no substance has ever been found in any of them, even after the most careful chemical analysis, that is not also found on our globe, although their constituent elements or substances are differently combined from those of Earth.

From this we learn the exceedingly interesting fact that the substances entering into the composition of other worlds are in the main like those composing our own. We already know that hydrogen and sodium exist in the Sun and Stars, and it is but reasonable to suppose that many other elements of Earth are found there, and in the other Suns or Stars, and also in the Planets. But we shall have much more to say on this subject in our article on Spectrum Analysis, by which new and wonderful science we learn the chemistry of the Sun and Stars.

The fact that these bodies so very closely resemble each other, leads to the supposition that they have a common origin, whatever that origin may be.

THE ALTITUDE OF METEORITIES

varies from 18 to 70 or 80 miles, that is of the visible

bodies. They doubtless are *orginally* at the distance of many millions of miles, but are at the aforementioned elevations when seen by us. They are seldom seen before coming within, or near the region of our atmosphere. It must be borne in mind here, that Meteorites are the *main bodies*, portions of which are thrown off at each explosion, and fall to the Earth, and are called air-stones, while the Meteorite itself dashes on in its unknown path—unknown because it becomes invisible soon after leaving our atmosphere, and therefore its path can no longer be traced.

THE MAGNITUDE OF THESE BODIES

is startling, and they are not at all welcome, though exceedingly interesting visitors when once safely deposited on the surface of the Earth. But it is not a very pleasant reflection that these fiery-visaged strangers, unlike the Moon and Planets, are at any moment liable to explode in mid-air above us, and rain down ten thousand tons of white-hot metallic or rocky matter upon our heads. Yet this has often occurred, as the surface of the globe clearly proves, and no one can tell how many a noble ship has been in an instant dashed into fragments, and her living freight, without a moment's warning, carried swiftly down to ocean's lowest bed, in horrible companionship with the white-hot, fiercely-hissing, ponderous mass. In 1807 a Meteorite passed over Weston, Connecticut, U.S., which was estimated to be 300 feet in diameter. Another, which dashed over Windsor, in 1783, was 3,210 feet, or more than three-fifths of a mile in diameter. That most extraordinary lady, the most gifted of her sex probably that the world ever saw, Mrs Somerville, mentions one of these frightful bodies that was estimated to weigh nearly 600,000 tons.

There is a most interesting mass of meteoric iron, now in Yale College, America, weighing 1,635 pounds, which was found in Texas. This is composed of pure *malleable* iron, with a small portion of nickel, and looks as if it had been subjected to some artificial process to purify it. From the fact that the metal is *malleable* we are sure that it has long been subjected to intense heat, as this is essential to its purification from the excess of carbon, which contributes so much to the brittleness of cast-iron. One fell in Siberia weighing 1,544 lbs. They are often at a white-heat on reaching the Earth, and frequently, when of great size, require several days or weeks to cool sufficiently to be closely examined.

These bodies evidently *revolve around* the *earth* a long time *before* striking it. How long can never be known. They may be thus circling around us thousands of years for aught we know, but with each revolution drawing nearer until at last their centrifugal force—that is the flying-from-the-centre force—is entirely overcome by the superior attraction of the Earth and they fall to the surface. But the *manner* of *their striking* the Earth, proves that they have been revolving around it, for they never fall *perpendicularly*, but invariably in an oblique line, as is most clearly shown by the cavity they make in the ground, which is always in a *slanting* direction. This, of course, could not occur did they come in a *straight line* from the abysses of space, directly to our globe. Their velocity, too, is far greater than if they fell merely from the force of gravitation. This velocity is more than 300 miles per minute. They strike the Earth with such tremendous force that they are sometimes buried to the depth of ten and twelve feet, and when striking upon a rocky surface are shivered

into thousands of fragments if they are composed of stony matter.

THE NUMBER OF AEROLITES

falling to the Earth must be immense. When we remember that three-fourths of the Globe's surface is covered with water, and that vast deserts and forests are uninhabited, and that a comparatively small part of the world is settled by civilized man, who would take note of and intelligently record these phenomena, and that those that are capable of making such record are for a considerable time wrapt in sleep, or, not observing the heavens—when we take all this into consideration, it is evident that the vast majority of these falling bodies entirely escape our notice when falling, and are never afterwards found. And yet, with all these disadvantages, a large number of these interesting bodies are found and distinctly recognised beyond the shadow of a doubt, as strange visitors from other worlds. From the number seen and known under these unfavourable circumstances, we may safely infer that the whole number falling must be immensely great.

OUR GLOBE INCREASING IN SIZE AND WEIGHT.

It is very clear from all this, that our planet is daily growing in bulk and weight, and that its attractive power is proportionately increased. It is impossible for the Earth to *lose* any matter. Whole cities and vast forests may be consumed by the flames, but in this there is no *loss of matter*.

It has simply changed its form, and what was solid has become chiefly gaseous under the influence of heat, while a considerable portion, by the same agency, has been changed into smoke and watery

vapour, and there is a small residuum of ashes. In a word, matter is indestructible. So also matter cannot *increase* on the globe, save by the falling of bodies from other worlds. The growth of an extensive forest, embodying in itself billions of tons of woody matter, would seem, at first sight, to contradict this, but when we remember that all that woody fibre of that vast forest was derived directly from the carbonic acid of the atmosphere, while a small proportion of the tree came from the soil, we shall again see that here is only a *change* of the *form* of matter, and no *actual increase*. But the constant falling of areolites not only increases the bulk, and weight, and attractive power of the Earth, but must in the course of long ages, work very important results.

Thus the Moon, by this increase of the Earth's attractive power, might be drawn so much nearer as to appear twice as large as she now does, and, as a consequence, give us twice as much light—almost converting the night into day, and permitting the prosecution of much important work during her presence.

But many thousand centuries must pass before this can be accomplished by falling Aerolites.

THE BRILLIANT LIGHT AND TRAINS

of Meteorites are accounted for by the fact that they are known to contain magnesia and potassa.

These substances, and their connection with the light and trains of these singular bodies, require explanation.

Magnesia is produced from the metal *magnesium* when it is made to unite with the oxygen of the air. Thus when a magnesium ribbon is burned, the metal unites with the oxygen of the atmosphere, and it

produces a light so intense that the eye is injured by looking at it, and the combustion is attended with a large volume of dense smoke. The ashes of the burning metal are magnesia.

Again, Potassa, or potash, is produced from the metal potassium when it also unites with oxygen of the air. Thus, when potassium is burned, the metal unites with oxygen in the atmosphere, and the ashes of the burnt metal are potassa, or potash. Potassium has such remarkable affinity for oxygen, that is, it unites so readily with it, that seemingly it can be set on fire by water. We shall fully explain this in another article, and give directions for performing this remarkable experiment.

Now, as we find the *ashes* of these two metals, magnesium and potassium, in the Aerolites in the form of magnesia and potassa, or potash, we may safely infer that the *metals* themselves were in these bodies while in the air, and that the burning of them produced the brilliant light, and that the long, lingering train was the result of the dense, luminous smoke attending this combustion.

It is highly probable that many of those brilliant bodies that leave behind them these long trains, but never fall to the earth, are *entirely consumed* in the air, being composed of these highly combustible materials. When we consider the immense number of them, we cannot but be impressed with a profounder conviction that a gracious and all-wise Providence is ever watching over us, and protecting us from harm.

Professor Newcombe, of Washington Observatory, one of the ablest astronomers now living, has estimated the whole number of falling meteoric bodies that annually dash thus fiercely toward our planet to

be 146,000,000,000. If one in a thousand of these bodies struck a human being, one-tenth of the inhabitants of the Earth would be destroyed in a single year. Think of the peril attending our daily journey through space. As we dash along at the rate of 68,000 miles each hour, we are assaulted on all sides of our globe by 400,000 of these bodies each twenty-four hours, and each one rushing toward us with a velocity many times greater than the swiftest cannon ball. And yet how effectually are we protected, and by what simple means. The all-wise and merciful Creator has arranged that the atmosphere we breathe to support life, and which so largely sustains also vegetable life, which refracts and reflects the light of the Sun, and also retains his heat, and serves so many other useful purposes, He has arranged that this atmosphere shall, in addition to all these, perform another service for us—that of warding off these violent intruders, and prevent the most of them reaching the surface of our planet. How wonderful is the divine government in the *natural* world! How do we on every hand see the footprints of Jehovah! How does He continually proclaim His presence "in all places of His dominion" by His wondrous works! It ever behoves us to remember Him as the everywhere-present One, who takes cognizance of all our acts.

As some have been inclined to doubt the existence of these aerolites, we shall, in our next article, give numerous well-authenticated instances of their falling to the Earth in the presence of competent witnesses, and also state where some of these remarkable masses from other worlds can *now* be seen.

ORIGIN OF AIR-STONES: INSTANCES OF THEIR FALLING.

We begin this article hy giving a few of the many well-authenticated instances of bodies falling from somewhere, and striking our globe, and shall afterward show whence they came, according to the theories of the present day.

From a very remote age these bodies have heen known to fall to the earth. Homer and Virgil speak of Shooting or Falling Stars, and among them doubtless were Meteorites, while Mahommed in the Koran refers to them as the visihle flames which the angels who guarded the constellations of stars, hurled at the evil spirits who came too near.

But there has been more distinct and reliahle reference to them in later times. In 1462, at Ensisheim, in Germany, a very loud explosion was heard at noon in the upper air, and a stone was seen to fall and hury itself deep in the Earth. It weighed 260 pounds, and hy the order of the Emperor Maximilian it was suspended in the church there, where it remained until the French revolution, when a portion of it was removed to the museum at Paris, and another part was taken to Vienna, and placed in the Imperial Cabinet, where they now are.

In 1627, another was seen to fall in the neighbour-

hood of Nice, which weighed 59 pounds. A blazing, hissing mass was observed in the Veronese territory to dash across the heavens with such velocity that the eye could scarcely follow its motions. This was in June 1635. Loud explosons were distinctly heard, and a large stone fell near the Benedictine Convent about six miles from Verona. In 1790, in the south of France, a glowing mass was seen, and after a loud explosion a shower of hot fragments fell of various sizes, and scattered over a wide area, some burying themselves in the Earth.

In 1795, in the afternoon of a very pleasant day, an explosion in the air was heard near Wold Cottage, in Yorkshire, and an Aerolite was seen to strike the Earth, which on cooling so as to be handled, was found to weigh 56 pounds. But these are comparatively of an insignificant character. In 1803 a large fiery globe of very great brilliance was seen rushing with startling rapidity through the air and passing over a greater part of Normandy, France. Frequent and loud reports were heard like the discharges of heavy artillery, and a very large number of air-stones or mineral masses were seen and heard to fall, widely-scattered, to the ground. Three thousand were actually found, and, of course, a large number must have remained undiscovered, as the explosions were at various intervals of time, and the stone-showers therefore very far apart, owing to the rapid motion of the body; and besides being at long distances apart, the explosions were so violent that the fragments were comparatively small and very widely scattered, so that large numbers must have escaped notice. The French Academy of Sciences appointed a commission to investigate the matter and make a report. At the head of this commission was the

distinguished M. Blot. Hence the report may be regarded as reliable.

The British Museum has a large number of these visitors from the deep abysses of space, and as the beholder gazes upon them, there must steal over him a feeling almost akin to awe as these mute masses, now lying so quietly before him, discourse, nevertheless, so eloquently of their mighty wanderings and tell of the profound depths from which they so recently came, and teach so conclusively the great truth, that matter is *everywhere*, and that *everywhere* is its great Creator—God. For, let it be here distinctly borne in mind, that in the minutest of these mineral or metallic masses we find illustrated the same laws of crystallisation that we know to operate in producing the beautiful and variously-formed crystals of earth—laws which have so often arrested the attention, and excited the admiration of the devout philosopher, because so clearly proving the existence of a universal superintending Providence, even in giving shape to inanimate matter.

In August 1810, an aerolite fell at Tipperary, Ireland. Two fragments of it were found containing quartz globules—glass-like round bodies—of a green colour, produced by the oxides or rust of nickel. In the valley of Berai, East Indies, three stones fell at the same time, at three villages, a mile distant from each other. Another fell at Drake's Creek, near Nashville, Tennessee, on May 9th, 1827. One of the weight of 66 pounds fell August 5th, 1812, at Chautonnay, France.

At Frettypore, India, on the 5th of November 1814, a blazing meteorite was seen just after sunset, shooting swiftly toward the northwest. It had the appearance of a blaze of light enveloping a red globe of the

size of the Moon. As it dashed on, explosions like the sound of distant artillery were heard, and a stone fell, throwing out sparks strikingly similar to those seen at a blacksmith's forge. When first discovered, the aerolite was quite hot, and gave out a strong smell of burning sulphur.

On December 11th, 1836, just before midnight, a splendid meteorite of extraordinary dimensions and brilliancy, passed over the village of Mocao, Brazil. The sky was perfectly clear, giving additional and startling effect to the beautiful phenomenon. It burst after being visible for some time, and a sharp, loud report was heard, and a shower of hot stones fell within a circle of ten leagues. The fact that these stones were scattered over a circular area, *thirty miles in diameter*, clearly shows that the main body exploded with great violence. The stones, as usual, were very hot, and weighed from one pound to eighty, and fell with such force, that notwithstanding the lateral, or sidewise direction received from the explosion, they penetrated the roofs of dwellings and buried themselves deep in the earth.

Sometimes the aerolite consists almost entirely of malleable iron. One of this character exploded with a tremendous report, over Upper Sclavonia, on the 26th of May 1751. Two of the many fragments were seen rushing to the earth, the largest striking deep into the soil. On being analysed it gave about 95 parts pure iron, and about 5 parts nickel. A part of the iron was finely polished, and then the polished surface was corroded with acids, and thus a beautiful crystalline structure was brought to light over the whole surface, which, doubtless, extended through the whole mass.

We might thus go on giving a list of a large number

of these interesting visitors from the regions of space; but these must suffice.

It now remains to consider

WHENCE COME THESE AIR-STONES?

There are several theories of their origin, some of which must be very briefly noticed, in order to be better prepared to judge correctly as to the source of these bodies. The first theory we notice is called the *Terrestrial Volcanic.* This supposed these air-stones to be thrown with such force from the volcanoes of the Earth, that they continued to fly through space, falling on various parts of the globe. This theory grew out of the well-known fact, that volcanoes do, from time to time, throw up vast masses of mineral and other matter. But there is no reason whatever to believe that any volcano of Earth has force sufficient to throw matter to such distances from them as we often find these bodies. For instance, these aerolites are often falling many thousand miles from the nearest volcano, and it is simply preposterous to suppose that they could be hurled to such a distance by any volcanic agency known on our planet. This theory, therefore, must be at once abandoned.

Another hypothesis is, that *they are thrown from* the *volcanoes* of the *Moon.* This theory is more deserving of consideration, for it is mathematically proven, that if a body were projected from a lunar volcano with a force which would carry it 9000 feet a second, then it would pass beyond the sphere of the Moon's superior attraction into the Earth's, and so would not return to the Moon, but fall instead to our globe, reaching it in about two days and a half.

But there are very grave objections to this also; for we have no reason to suppose that any lunar

volcano can hurl a mass of matter of such size as often falls to earth, with a velocity four times greater than a cannon ball, which would be necessary to send them to the Earth. Besides, these bodies have been falling for thousands of years, and as already shown, in large numbers; so that did they come from the Moon, that body must be already so much reduced in size that its motions would be materially and perceptibly changed; but no such change whatever is observable in the motions of the Moon, and therefore this theory, too, has been abandoned.

Still another theory is, that aerolites are formed in the atmosphere from gases and exhalations, or the rising of very small particles from the surface of the Earth, very much as rain, snow and hail, are formed from the evaporations of the seas and oceans, being condensed and solidified in the upper regions of the air like them. But there is an unanswerable objection to this theory furnished by the balloonist. Aeronauts have collected portions of atmosphere at great heights, and keeping the vessel perfectly close, on reaching the surface, it has been carefully analyzed but no such substances were ever found in the air even in minutest quantity, either at the highest altitude, or on the surface, as are found in these mineral and metallic masses so often falling on our world. But even were such substances in the air, but in such exceedingly minute quantities as to prevent detection, it seems preposterous to suppose that they could be suddenly solidified in such masses weighing sometimes tens of thousands of pounds. Hail-stones never are formed of several hundreds or thousands of pounds weight; and yet the material for hail is vastly more abundant in the atmosphere than can possibly be mineral or

metallic matter. This supposition therefore must also he ahandoned.

The theory remaining to be examined is the *Planetary*. This is now very generally regarded hy our ahlest scientists as the true theory of the origin of these remarkahle hodies.

According to this theory there are vast numhers of these hodies revolving around the Sun at various distances and of different magnitudes, hut moving like the planets in one direction, and in reality, constituting the smaller memhers of our great family of worlds, called the Solar System.

These hodies are not *ordinarily* visible because of their small size; not heing ahle, in consequence of their minuteness, to make themselves seen hy the little light they reflect from the Sun. But, when they happen to approach so near the earth that they enter our atmosphere, then the friction and compression of this atmosphere as they dash through it so heats them, as already shown, that they become intensely bright, and explode in consequence of all parts not heing heated alike, upon the same principle that a glass vessel cracks when suddenly immersed in hot water.

But there is a question hehind this: Where were these bodies *before* they commenced revolving around the Sun? This is answered with at least some degree of certainty by a comparatively recent and very remarkahle discovery.

Prof. Graham, the master of the mint, and one of the ahlest chemists of the age, examined an iron aerolite that fell at Lenarto.

The examination was with special reference to the existence of hydrogen in the iron, and though the iron was remarkably pure and malleable, proving

that it had been subjected to great and long-continued heat, yet he found more than *three times* the ordinary quantity of hydrogen shut up in this meteoric mass.

Now, how was this quantity of hydrogen gas, so much greater than ever found in the iron of Earth, to be accounted for?

The only explanation that is satisfactory is this: That iron, when in a melted state, was somewhere where there was an atmosphere composed chiefly of hydrogen, and that atmosphere *pressed* upon that melted metal with a force unknown to our globe, so that the hydrogen gas was forced in large quantity into the minute pores of the melted iron, and on cooling, this gas was *detained* in the pores, as when found and analysed.

But *where* was this tremendous pressure exerted? Evidently nowhere but on some great Sun, our own or some other Sun. Now, we know that hydrogen exists in large quantity on several of the Stars or Suns. Spectrum analysis has clearly proven this; therefore, we are led to conclude that these mineral and metallic masses falling so frequently to our globe, came originally either from the Sun or from the Stars—the other Suns of the universe. Thus, then, this mysterious body comes to us, bringing the hydrogen of the Stars, locked up in its minute cells.

These bodies were shot forth from solar volcanoes with a force that sent them out into space so far that instead of returning *at once* to the solar surface, they revolved around him, prevented from returning, in part, by that mysterious *repelling* force of the Sun spoken of in a former article. These bodies in their revolutions, at times, come so near the Earth that they are drawn out of their orbits, and after revolving around our globe, perhaps thousands of years, at last

are attracted to the surface, and dash upon it with terrific force.

It must not be supposed that *all* this is clearly and conclusively demonstrated; but this, in its main features, is probably the true theory of the origin of aerolites.

Of the number of these wondrous bodies thus dashing through space around our own, and billions of other Suns, mortal man can never know. There may be sufficient to form, when all collected, thousands or millions of new worlds.

THE ORIGIN OF WORLDS.

No. 1.

When we speak of the *origin* of worlds, we have reference simply and only to the *mode* of their production and formation—the *means* employed by the Supreme Being for the accomplishment of the stupendous end. The question of their *first coming into existence*, is fully, and to every right-minded man, satisfactorily answered in the Divine Oracles—"In the beginning God created the heavens and the Earth." While we reverently receive this sublime announcement with full and unquestioning faith, we may, nevertheless, with perfect propriety humbly inquire respecting the *probable mode of operation* in this most amazing work. It is to this great question that we now direct our attention.

At the outset, then, we assume that the *materials* for world-making have already been brought into existence from nothing, by the Almighty Fiat, or decree, but as to the *mode* of their *then* existence, the Sacred Scriptures give us no definite information, save the simple declaration, that "*The Earth was without form and void, and darkness was upon the face of the deep*," which very clearly implies an altogether different condition from its present state.

FIRST CONDITION OF MATTER.

What was this condition? The theory which has

received the most favourable consideration is that of the distinguished astronomer, Sir William Herschel, and called the Nebular Theory; and also known as La Place's theory, because that eminent French philosopher still further expanded and applied the grand conception of Herschel. According to this hypothesis, or theory, *all the matter of the whole universe was originally in a gaseous or vaporous state*, and was gradually condensed by the action of the law of gravitation—each particle of matter attracting its fellow particles, and thus, in process of time, solid globes were formed. Let us look for a moment at the wondrous revelations of Sir William Herschel's great telescope, which revelations first suggested to him this grand conception.

HOW HERSCHEL FORMED HIS THEORY.

It is well known that this great philosopher, after the most arduous and long-continued labour, constructed a monster telescope, vastly superior to all other instruments then known to man. With this gigantic apparatus, having a reflector four feet in diameter, and a tube forty feet in length, Herschel discovered a most wonderful object far out in the abyssmal depths of space.

It was, apparently, a misty, nebulous, or cloud-like mass, faintly luminous through its whole extent, save in the centre, where shone forth with dazzling brightness what seemed a great central Sun. At first, Herschel supposed this faintly luminous matter was a mighty congregation of suns, but at such immense distances from the bright centre, that they could only be thus faintly visible. This appeared the more probable as his great telescope had already proven other bodies that had presented the same nebulous

aspect in smaller instruments, to be vast aggregations of solar centres.

Continuing his explorations, he was amazed to find numerous other bodies, presenting the same nebulous, or hazy appearance, with a star more or less bright, in the centre. The idea first entertained, that this misty matter was a vast assemblage of suns revolving around a vastly greater centre, was now abandoned in these particular cases, because, the distance from the central sun at which these suns must be placed to be so faintly visible, was entirely disproportionate, and too great according to revelations in other quarters of the heavens, in the case of similar bodies. What, then, was this hazy envelope of the central, glowing mass? If not a vast congregation of Suns, what else could it be? This was the great problem to be solved.

A GRAND CONCLUSION REACHED.

After patient and most exhaustive labour, Herschel reached the grand conclusion that this nebulous envelope was *matter in its original chaotic state* as it came from the hand of its Creator, somewhat, probably, more condensed, but still in a vaporous condition, and now in process of further condensation around the already semi-solid, glowing, central mass; *glowing*, because of the immense friction of the particles, consequent upon their condensation, and this condensation produced by the force of attraction.

Here, then, was the starting-point for an entirely new theory of creation.

With the aid of his great telescope, he saw before him, in the vast abyss, a world in the very process of formation—a half-finished world, so to speak; a world that might require ten hundred millions, or even billions,

of centuries more to finish it; a world *now* in the very condition in which was once our own. From what he discovered in this and other similar bodies, Herschel reached the sublime conclusion that, originally, *all the matter* now composing Sun, Moon, Planets, Comets, Meteorites, Stars, and whatever other unknown bodies may exist, was originally in a *gaseous* or *vaporous* state, and diffused throughout space in the most attenuated, or thinnest condition of which we can have any conception. That the same Almighty Creator, who had, by a word, brought this vast mass of misty matter from nothing into existence, at a given time, gave to each individual particle of it the power of attraction, when, in an instant, throughout this entire mighty mass, motion commenced, particle rushing to its nearest particle, and these two united particles drawing a third, and these three drawing—now with greater force—a fourth, and thus, from centre to circumference, all through that measureless mass, this rushing of atom to atom went on, changing in an instant, what was, perhaps, to a created eye, an almost invisible substance—by reason of its extreme tenuity, or thinness—changing, instantaneously, all this thin, invisible matter into visible form.

CENTRES OF AGGREGATION.

That the same Almighty Creator, in His infinite wisdom, established at certain points *centres* of *aggregation*—that is, centres of attraction—toward which centres all the matter within billions and quintillions of miles of each such centre, should at the same moment begin to move, and thus, at these various centres of attraction, were formed the nucleuses, or cores of future sun-worlds. According to this theory, further condensation and consequent friction engen-

dered intense heat, and when, after myriads of ages, the collection of matter at these points had left each great mass detached from all the rest, so that there were vast vacant spaces between them, from which all, or nearly all, the matter had been withdrawn, then, these various masses by the same Almighty Hand, were set in motion on their axes. It will be seen from this that each mass must necessarily have been globular, as matter rushed equally from all points to the centre, and thus as the body grew from these accumulations on every side, it naturally assumed a spherical form. As yet there were no planets in existence. One great nebulous mass, more than six thousand millions of miles in diameter, extended *outside* of the limits of the whole solar system. The matter *now* composing our globe and all the other globes of our family of worlds, was *then* enfolded *in that great nebulous body* in a state thinner than any visible matter now known to us on Earth.

HOW PLANETS WERE FORMED.

Thus were formed the great centres of future systems—our sun-worlds. From the revolution of these great masses on their axes, according to this nebular theory, other worlds were formed.

Thus, to illustrate: when a round body is set in rapid motion on its axis, any loose matter on its surface will be detached from it, and either be thrown out in fragments into space, or revolve around it as a ring entirely separated from the central body.

Thus, if a grindstone or carriage wheel be made to revolve very rapidly, the water on the surface is thrown off in tangent lines. Again, if a bucket with a small quantity of water in it be suspended vertically by a cord, and the cord be tightly twisted, and then

allowed to unwind itself, a rapid rotary motion will be obtained, and the water will form a perfect ring against the sides of the bucket, leaving none in the centre, and will so remain so long as the rapid motion continues. This is owing to what is termed the *centrifugal* force produced by the revolving body.

In the same manner, and by the operation of the same law, and *aided* by the *contracting* and *condensing* of the *inner portion* of these huge, revolving sun-worlds, these mighty globes threw off immense rings, which became new centres of attraction, and furnished the materials for planetary worlds, the rings breaking and the fragments uniting by their mutual attraction; while in some instances, as we shall hereafter see, these rings remained *unbroken*, as we find several of them to be to-day.

These planetary bodies would revolve around the parent mass and in the same direction, while the process of condensation, shrinking, or contraction would continue until another ring would be formed and detached from the great revolving body, and this ring breaking as before, the united fragments would form another planet moving as the first, around the parent globe, and in the same direction as that globe turned on its axis. And thus this condensing and shrinking, and formation and detaching, and breaking of rings, and uniting of fragments, would go on, until a whole system of planetary worlds was formed, and all revolving around the great original mass as a centre.

HOW MOONS WERE FORMED.

But this is not all. We are yet to show how Satellites or Moons were formed. To enable the reader to understand this, we have only to state that

these *new* bodies, formed from the detached fragments and broken rings, began at once the same process of condensing and shrinking as did the body from which they came, and in some instances with the same results. Thus, from a continued shrinking and condensation of a planetary mass there would be formed a ring as before, or fragments would be thrown off, and these fragments uniting, would make up a Satellite or Moon.

But where a ring was formed and that ring remained unbroken, we should have a planet accompanied not only by one or more Moons, but also by one or more rings, all revolving around the body from which they sprang.

Now, have we anything in existence to-day to substantiate this remarkable theory of creation? Let us see.

If we look at the planet Jupiter, we find revolving around him four beautiful Moons, as revolves our Moon around the Earth. Going outside of Jupiter, we find the planet Herschel accompanied by six Moons; and between these two planets we find—what is most wonderful of all as evidence of the truth of this Nebular hypothesis—a planet with no less than *eight* Moons, and what is still more amazing, *five* of these wonderful rings, all unbroken, and all revolving with the eight Moons around the parent planet, the rings being all in the same plane, and just over the *equator* of the planet—precisely where we would expect to find them according to the requirements of this theory. Now here is seemingly most conclusive proof of the soundness of this theory of Herschel. Furthermore, there are found by the aid of our largest telescopes, scattered over the heavens, numerous planetary nebulæ in various stages of condensation, some having a very faint central star, or

head, indicating that the body is not yet sufficiently condensed to give forth much light; and others intensely brilliant, and surrounded by a more luminous envelope than the other nebulæ. All this is favourable to the hypothesis of Herschel and La Place.

There is another point to be noticed. In the formation of these great centres of aggregation around which gathered those mighty globes billions of miles in diameter, there would naturally be left between these globes masses of this original matter. They would be left, because, being on the outskirts of two globes at the beginning of their formation, they would be about equally attracted in both directions, and therefore would unite with neither, but remain midway between the two masses.

Thus there would be scattered throughout the universe numerous detached masses of vaporous, chaotic matter, and located in the vacant spaces between the great Sun-worlds, held stationary for some time because of the equal attraction on every side, until at length the body, by some more powerful attraction in some direction, would begin to move slowly toward one of these great Suns, and as it approached nearer the great mass, would rush with greater velocity toward it, and dash around it with frightful speed as it plunged again into the profound abysses of space. The reader will perceive that all this is strikingly in correspondence with what is seen in the motions and appearance of Comets; and hence it is inferred that while many of these mysterious bodies—Comets—are probably projected from Solar volcanoes, it is also probable that some have such an origin as just described. This is rendered the more probable, as Comets come to us from all quarters of the heavens, just as we would expect from the hypothesis under consideration.

THE ORIGIN OF WORLDS.

No. 2.

In our last article we presented the theory of the *Nebular* Hypothesis of Herschel and La Place, which accounts for the origin of all Worlds by supposing them all to have been at first in a gaseous or vaporous condition, and this gaseous matter to have heen spread out evenly through space, and that at a certain time Jehovah gave to each particle of matter the power of attracting every other particle when, in a moment, all through this immeasurahle, misty mass motion hegan, each particle seeking a union with its nearest particle, and this now douhle particle attracting a third, and so on until a nucleus or core was formed. These nucleuses or cores were the centres of aggregation or attraction. Again at a certain period the same Almighty Hand set all these great, half-condensed globes in motion on their axes, and by their shrinking or condensing at their central parts, and also by their rapid rotation on their axes, there were raised at the equators of these revolving glohes great rings, and that these rings were at length detached from the main body, and breaking into fragments, these fragments united hy mutual attraction, and formed another glohe which revolved around the parent mass as a planet. After this, the planet also by condensing at the centre, and hy its rapid

rotation on its axis threw off a ring, as before seen, and this ring breaking and the fragments uniting, a satellite or moon was produced which revolved around the planet as the planet revolved around the first great globe; and thus the work of condensing and throwing off rings and their breaking and uniting went on until a system, or family of Worlds was produced like our own. In this way, according to this theory, all the stars were produced, and all the Worlds revolving around them.

Now while this sublime theory is very generally received as the true one, and explains many phenomena and facts which cannot so well be explained by any other, still there are objections to it, and some very eminent astronomers have not yet fully accepted it as the true history of creation. There is, therefore,

ANOTHER THEORY OF CREATION,

which has received very favourable consideration, and this I now present. It is called the Theory of Meteoric Aggregation, and cannot but excite a deeper interest in this subject.

The hypothesis takes the ground that there are scattered through space innumerable masses of matter of various quality, magnitude and form, and that immense numbers of these are now revolving around the Sun, and have been so revolving for uncounted ages. They move generally in the same direction as the planets, from west to east, at various distances and with different velocities. But those revolving around the Sun are not *all* that exist. They are supposed to be scattered throughout all space, and to be moving in every conceivable direction, and to be even to-day almost innumerable. But in the remote ages of the past these bodies were inconceivably

more numerous than they are to-day; for it is evident that the number must be greatly reduced from the well established fact that so many hundreds of thousands now fall annually on our globe, and that this rain of air-stones has been going on not only from the earliest history of man, but for unknown millions of years before our race was placed on this earth.

And not on our globe only do these mysterious masses fall. We have seen in a former article that many million times more must dash into the Sun with terrific speed and force, drawn by his vastly greater attractive power. And not on Sun and Earth alone do these visitants from deep space descend, but also upon all the 175 worlds now known to belong to our system, the number falling upon each, being probably somewhat in proportion to its quantity of matter, as that quantity of matter determines its attractive power.

Thus we see that the Sun and all the members of our world-family are, so to speak, engaged in the stupendous work of *clearing out the heavens and sweeping up the sky*, and gathering the world-dust and star-dust into the great garners or dust-heaps of the universe.

This work of collecting the scattered fragments of matter into great heaps is going on through all space. On this we can have no doubt, as it is already proven that the law of gravitation is the law of the *whole material universe*; in other words, matter attracts matter wherever matter is found and always in proportion to its quality. Now as this great work of fragment gathering has been going steadily on for so many hundreds of thousands of years, and is not yet complete, we may very safely assume that all the

regions of space have been once far more thickly strewn with these fragmentary masses than they are to-day.

It is also evident that in the process of ages the time will come when *Air-Stones will cease to fall on the Earth,* but in all probability that day is exceedingly remote when the *last* aerolite will strike our globe—when the heavens will be so thoroughly swept that there is not another left to fall.

Nevertheless, that time will come, when the inhabitants of Earth will no longer be subjected to danger from this source.

These meteoric masses, according to this theory, are supposed to have thus existed from the first dawn of creation, or to have been soon after formed into these solid masses by the combined agencies of attraction and heat.

Thus, at first it is supposed the particles of matter existed in a somewhat more *solid* form than as contemplated in the Nebular hypothesis, where, it will be remembered, matter is stated to have been originally in an exceedingly attenuated or *thin* state, and very gradually solidified.

In this theory of meteoric aggregation the *original* matter is supposed to have united with more energy, and then, once united, heat was produced by the friction of the ether through which they were constantly and rapidly moving as they travelled around the Sun ; and this heat, thus produced by constant friction, soon solidified the bodies to the degree of hardness in which we find them on falling to our globe.

It must be frankly admitted, as already stated, that there are some objections to this theory, as there probably will be, in greater or less degree, to all

others. Probably, to the end of time, there will be many questions upon which the *whole* scientific world will never be fully agreed; and much that is mysterious and overpoweringly wonderful is perhaps purposely reserved by infinite Wisdom for investigation in a future state, that there we may see still more of Divine power and glory.

Now, according to this theory of *Meteoric Aggregation*, these masses of various quality and magnitude —when once formed, as stated, by the mutual attraction of a number of particles commenced moving to various centres of attraction, which were appointed by the all-Wise Creator.

Among these centres of attraction that of the Sun was the most powerful in our system of worlds—though very far from being the most powerful in the universe—and to this, therefore, the largest number ofmeteoric bodies would naturally tend, thathappened to be in its vicinity, and this, therefore, would grow more rapidly than the rest, and the tremendous fall of meteoric bodies all dashing with such terrible energy upon the Solar surface would engender the most intense heat from the constant and violent friction of these bodies against each other in falling, and in striking the surface of the already glowing mass. At other points in the vicinity of this central solar formation there would be other centres formed, which would vary in magnitude, as we shall see.

Some would be quite near comparatively to the Sun, and these would not be able to draw and hold all the bodies that at first started toward them, as they commenced moving, out in the remote depths, because the far more powerful attraction of the central orb would cause them to dash by the smaller globe and rush on to the greater and more powerful

centre the Sun. Therefore those centres near the Sun would be able to intercept only a few of these rushing masses, and only when they moved directly, or nearly toward their centre. Hence these worlds near the Sun would be comparatively small. But on the outskirts of the system, where the attractive power of the great central mass would be far less powerful, it would be easier to intercept a passing body and draw it to a given centre, even though it were not moving directly toward that centre, and thus a much larger number of these wandering masses would be arrested in their flight, and would gather at one or more of these outermost worlds, and we would expect, therefore, according to this theory, to find these outer worlds much larger than those *within* the system. Now this is exactly what we do find in our family of worlds. The planets nearest the Sun are the *smallest* in the system, save the planetoids, or asteroids, as they are called, because they are somewhat *like* planets, rather than actually and properly belonging to that class of worlds.

And on the other hand, the larger members of our family are toward the outskirts of the system, the largest now known being about midway.

This theory of Meteoric Aggregation, therefore, explains *some* facts more satisfactorily than does that of the Nebular Hypothesis; but there are some other features of our system which it does not so fully account for; as, for instance, the formation of the rings of Saturn, and his large number of moons.

It must be conceded that the Nebular Hypothesis, in respect to these last wonderful formations, seems the more philosophical, and in more general accordance with these and other well-known facts. But we

need not expect, with the present stage of astronomic science, to find any *one* theory explaining *all* the phenomena of the heavens; we shall probably be obliged to look, for the solution of many mysteries, to *parts* of *different* theories, and out of these *fragments* of theories construct one differing from them all. But for this *perfect* system we must yet patiently wait, until improved and more powerful instruments shall enable us to study more successfully these truly wonderful works of the Almighty Creator.

SPECTRUM ANALYSIS.

No. 1.

We come now to one of the most extraordinary discoveries in Astronomic Science of modern times. The old Astronomers never, for a moment even, dared hope that they would ever ascertain the constitution of the stellar worlds, and actually learn what substances were being consumed in the flames of suns so distant that their light required ten thousand years to reach us. And yet this astounding success in science has been achieved, and we are now permitted to speak—and speak with confidence—of the *Chemistry* of the *Stars*, as made known to us by this new science, called Spectrum Analysis.

By spectrum analysis is meant the chemical analysis of substances by means of their spectra.

But the term "spectrum," and its plural, spectra, as here used, may require explanation. We begin with the *Solar* spectrum. When a beam of white or Solar light is passed through a triangular prism of glass, we find it is separated into seven or eight primary colours—the colours of the rainbow. These, collectively, are the Solar Spectrum. This may be easily formed by any one, by procuring a triangular piece of glass at some manufactory, or by getting a tinsmith to place in a triangular tin frame three pieces

of clear, white window glass, and after making water-tight, fill with clear water.

On allowing the sunlight to pass through, a most beautiful spectrum will be seen; or a somewhat similar effect is produced by simply looking through a side of the prism toward a strong light.

The light from a star gives also a spectrum. And so from the light of other burning bodies there are spectra also. The solar spectrum was found by Fraunhofer to be crossed at right angles by a large number of dark lines, and these are called "Fraunhofer lines" in honour of the discoverer.

Kirchoff, a German philosopher, in 1859, discovered the real character of these lines, and their important significance respecting the physical constitution of the Sun, and other heavenly bodies. Bunsen, Huggins, and Whinnike have also contributed much to the advancement of this most modern of the sciences. But these cross lines of the Solar spectrum of Fraunhofer, as stated, are dark. When the instrument was directed to some other luminous bodies, it was found that the cross lines of the spectra were not dark, but of various bright and beautiful colours.

So, also, when the spectrum of a *gaseous* body in which some foreign substance was burned, was formed, it was invariably found that their cross lines were not dark, but of various beautiful and brilliant colours, and always *varying in number*, according to the *number* of *substances* burning in the flame. It was also discovered that each substance burning, *always* gave forth its *own peculiar* system of lines, and still further, that these were *invariably* of the *same number*, of the *same colour*, and in the *same* place.

Here, then, was the *foundation* of this most beautiful and most wonderful science of Spectrum Analysis.

On these few but remarkable facts, that *any* substance in burning, *invariably* gives forth the *same number* of lines and of the *same colour* and occupying precisely the *same place*, the whole science rests.

Thus, sulphur in burning, gives a blue flame; sodium, a yellow; silver, green; strontia, the beautiful crimson, so often seen in pyrotechnic displays.

This remarkable science, with its comparatively cheap and simple apparatus, has already done more to enlighten us respecting the chemical constitution of the stars, than any telescope has ever done, or ever can do, however large its aperture, perfect its construction, or great its cost. It has, in a word, revealed to us the constituent elements of the stars. It has taught us, not only the chemistry of the stars, but also the constitution of all those wonderful bodies brought to view by the telescope.

It has made known to us the startling fact that many of the elements entering so largely into the composition of our globe are found also in the remotest Stars, and thus also led to the grand hypothesis that the matter of the *whole universe* is, probably, essentially the same as that composing our globe. Let it be observed here, that this last is only a hypothesis—a supposition—which can never be *fully* established.

But we must here look at the simple instrument by which these startling results are secured. This is called

THE SPECTROSCOPE.

It consists of two or three small telescopes of low power, and a triangular prism of flint glass. In the eye end of one telescope, instead of the usual eye-piece, there is an adjustable narrow slit, varying from

one thirty-second to one three-hundredth of an inch wide. Through this very narrow aperture the light of the Sun, or of a Star, or of a flame, to be examined, is made to pass and fall upon the object glass, that is, the *larger* glass—of the telescope. The rays of light, in passing through this object glass are made parallel. They then pass through one or two triangular glass prisms, and the light is thus refracted—bent out of its course—and decomposed—separated into its eight primary colours, violet, indigo, blue, green, yellow, orange, red, and lavender—this last seen only with proper instruments. Thus a small solar spectrum is formed, when sunlight passes through.

This minute and exceedingly beautiful spectrum now enters a second telescope, or, more properly, perhaps, a microscope, where it is seen by the observer under high magnifying power, and those heretofore mysterious and very peculiar cross-lines are now first discovered—those marvellous lines, the wondrous, silent, but most eloquent messengers from the fathomless abysses of space, telling us, with no faltering voice, their marvellous story of the Stars.

And what is their story? This: That far out in that fathomless abyss—so far, that though travelling with lightning speed, they have been thousands of years in bringing us the message—that far out in those profound depths of immensity there are chemical operations going on, upon a most stupendous scale, precisely the same as on our globe; that on those mighty Suns which we call Stars, there are various substances similar to many on our own planet; that our Sun, too, like these other Suns, has these same substances of earth; and that these substances both on our Sun, and on the mightier Suns beyond, are in

an incandescent state—that is, are at a glowing heat in an ocean of burning gas; and that this is one source of the light and heat we enjoy. Such is the story of these simple but wondrous cross-lines, given through that marvellous instrument—the spectroscope.

But let us look more particularly at its mode of operating, in telling us this wondrous story of the Stars, and also at some of the amazing results.

If a white-hot cannon ball be placed before this narrow slit of the instrument, its light will give a *continuous* spectrum; that is a spectrum *without any cross-lines.* But if we place before this slit a gas-flame, or the flame of a spirit lamp, and in this flame place some soda, we shall then have in the spectrum two bright *yellow* lines, both in a *certain part* of the spectrum.

If now we place in the flame some preparation of silver, we shall have two beautiful *green* lines. Sulphur will give us *blue* lines. Strontia two bright *crimson* lines. Now let it be carefully observed, that these various lines will *always* be found in the *same position* in the spectrum, and will also be invariably of the *same number.*

Still farther: On being carefully measured by a third telescope, or microscope, having a delicate scale attached, these lines will generally be found the *same distance* apart.

And now comes a startling fact: If all these substances, and many more be burned at the *same time* in this gas, or spirit flame, we shall then see, at the *same moment*, all their beautiful and characteristio lines in the spectrum, and *each one* in its *proper place!*

This is a most beautiful and startling sight. Let

us reflect a moment upon it. These substances are necessarily mixed, and very intimately mixed together in the flame, while in the burning process, and yet the *colour* of *each one* is *sifted out* by this magical apparatus, and appears as distinct as if it were the *only substance* in combustion!

So invariable is this that the *slightest* trace of any one of these substances in the flame can be immediately detected by its corresponding line or lines, and hence the science has been made available, not only in determining the chemistry of the Stars, but also in analyzing various substances of Earth, while undergoing combustion; their brilliant and delicate cross-lines being always distinctly seen, however small the quantity of matter present. With some chemists this is now a favourite mode of analysis for determining the presence of bodies, both for medical and scientific purposes, in consequence of its great accuracy.

Let us now vary this interesting experiment. We will place *behind* this gas, or spirit flame, in which these various substances are burning, a cannon ball at a white heat; and instantly all these *bright* and beautifully-coloured lines disappear, and in their stead are seen *dark* lines, but the *same* precisely in *number* and occupying the *same position* as when of different colours. These lines will continue dark as long as the white-hot cannon ball is behind the flame, sending its light through the gas flame into the narrow slit of the spectroscope. But let us for a moment remove the cannon ball, and in an instant all the beautiful lines with their appropriate colours appear. Introduce again the incandescent white-hot ball and once more they are deprived of all colour and appear only as dark lines. It must be carefully

borne in mind here that the *colour* of the lines alone will change, the number and position, as stated, remaining the same.

Now let us see if there is any practical value in these experiments, in our investigations of the Sun. If we direct the spectroscope to that body, we find, as already stated, his spectrum crossed by numerous dark lines.

These lines are not scattered at random over the spectrum, but grouped in regular systems. For example—there are two dark lines occupying the place of the sodium lines, others in the places of the Strontium, Calcium, and Cadmium lines, while about seventy are found in the place of the iron lines. Now, let it be fully understood that all these lines are in precisely the *same position* in the Solar Spectrum, in which we find the bright lines representing these various substances when we burn them in the gas, or spirit flame, or in the galvanic focus. In other words, the results are the same as when we place a white-hot cannon-ball behind a gas flame in which these various substances are burning. From some unknown cause, a flame will not allow the same rays which it emits to pass from another body through itself.

Thus, the white light from a white-hot cannon ball will pass all its rays through a *soda* flame except the *yellow*—these yellow rays being the colour of the soda lines. These yellow rays seem, in some way, to be absorbed by the soda flame, so that in place of the yellow, there will appear dark lines in the Spectrum, but the *same* in *number* and *place* as the yellow. So when any other rays are passed through flames of the same colour, *dark* lines are seen.

Now what is taught us by all this? Nothing less

than the great truth—and which seemingly could not possibly be taught us in any other way—the great truth that the Sun is a white hot or molten mass, and surrounded hy an ocean of gas of immense extent, and that in this gas ocean there are hurning various substances, such as sodium, nickel, iron, zinc, calcium, harium, magnesium, chromium, cadmium, hydrogen, &c., and that these are the cause of the dark lines seen in the Solar spectrum.

How eloquent is dead matter? How overwhelmingly significant are the most *trivial* phenomena when rightly understood! How do they all, as with one voice, speak of a Higher Intelligence? All nature is vocal in praising its Great Author. Let not rational man, created in his Maker's own image, alone be dumb!

SPECTRUM ANALYSIS.

No. 2.

In our last article we gave an outline of this new science which has so unexpectedly unlocked the secrets of the Universe, and enahled us to penetrate into the hidden mysteries of so many worlds so much grander than our own.

In closing, we gave a few of the substances now known to exist in the Sun. Let it not be supposed, however, that the list is exhausted.

On the contrary, many more have been discovered, and others are heing brought to light by means of those tiny, and seemingly insignificant, dark lines, which have come so far to tell us of their wondrous origin. It is proper to remark here that if the Sun were simply a *gas*-world, then, instead of these *dark* lines, the solar spectrum would exhihit all the beautiful bright lines so distinctly seen when these corresponding hodies are burning in a gas, or spirit flame, or still more, in the focus of a powerful galvanic battery.

To prove that there is no mistake in the conclusions reached from spectrum analysis, and that we are not dealing in mere conjecture, the apparatus is sometimes so arranged that the light of the Sun, and also artificial light—as flame in which these various substances are burning—can both be admitted into

the spectroscope at the same time. When this is done, a wonderful and most gratifiying result is secured, that must satisfiy the most incredulous. It is this: There, side by side, are the *two spectra*—that from the Sun, and that from the gas or spirit flame in which various substances are being burned. One, that of the Sun, has the dark lines; the other the bright; but—and this is the marvel—both these sets of lines are in *perfect correspondence*, both in respect to *number* and *place*, differing only in *colour*. This settles conclusively the question as to the reliability of these investigations of the chemistry of the heavenly bodies by spectrum analysis.

We come now to the spectra of the Stars. Hitherto, we have had no *positive* evidence that these bodies were actual Suns like our own, although it was generally supposed, and with good reason, that they were so.

They were supposed to be Suns because of their visibility, notwithstanding their immense distance, as *reflected* light could not, under any circumstances, be seen so far.

Their great distance was proven by the absence in many instances, of any parallax, that is, change of place when viewed from very distant points; even when seen from opposite sides of the Earth's orbit—a distance of 384,000,000 miles. Still further proof of their remoteness is furnished by the startling fact that the most powerful telescope Earth ever saw cannot in the least degree magnify the Stars; their *brilliancy* only being increased by these mighty magnifiers as proven by the fact that a spider's thread will wholly shut out from view any Star seen in the greatest magnifier of the world.

This shows beyond doubt, that they are, even in

these huge instruments, mere *points* of light. All this is, at least, strong presumptive evidence, that these Stars are Suns, as they could not be seen by us at such immense distances, if they shone merely by *reflected* light.

But satisfactory as was all this to astronomers, we needed something more to fully establish their solar character. In the simple and small spectroscope, as remarked, we have an aid more powerful than in Earth's greatest refractor or telescope.

In making our observations with the spectroscope on the Stars, as they are comparatively faintly seen, we need more light than the eye alone can receive, and therefore we attach the spectroscope to the telescope, not to magnify, but simply to collect more light.

To the experienced astronomer the results of this experiment are not so surprising, as he has long felt that these far-distant, twinkling orbs were not mere *reflectors* of light, but original sources of it; and yet he could not *fully* prove it. But now he can prove it, and not by mere mathematical, but by *ocular* demonstration. There, in those tiny, dark lines of the spectrum, is the overwhelming evidence that each Star is a mighty Sun, shining by its own native light, and similar in all its principal features to our own Sun. There, in those apparently insignificant lines, is the proof that it is either a solid or a molten mass of white-hot matter, sending its fiery rays through an ocean of gas-flame on every side, and that fire-ocean extending out from the solar surface thousands of miles; while in this heavy, metallic, fiercely heated, raging atmosphere, metals and minerals, clays and sands, earths and rocks are being consumed as readily and completely as the dry stubble before the devouring flame.

Turning this magical instrument to another Star, and the results are essentially the same. And to another, and they are the same; and so the grand conclusion is satisfactorily reached at last, that all those faintly twinkling orbs are the luminous centres of mighty systems of worlds, to which they impart light and heat, as does our Sun to our own family of worlds. But this is not all that the spectroscope has done for us. It has settled that question of absorbing interest respecting the constitution of the nebulæ. By the nebulæ are meant those faint wisps of light occasionally seen in the absence of the Moon, and in a very clear sky. The Milky Way is an immense nebula, or rather a vast congregation of nebulæ, more distinctly visible than most of the smaller, because probably nearer to us. Many of these can be seen only in a powerful telescope.

Large numbers of them have been shown by our most powerful instruments to be vast congregations of mighty Suns, each Sun having, doubtless, its own retinue of worlds circling around it as our great world-family revolves around our great solar centre. They are vast systems of systems, "island universes," seemingly, apart from the rest of creation, and governed by their own internal laws.

Now, as so many of these nebulæ have been thus discovered to be immense systems of systems, it was confidently expected that such would be the result in examining them all. But here there has been an overthrow of a fondly cherished theory.

Our great telescopes have not only failed to separate some of them into individual Stars, but the spectroscope has conclusively proved, that some of them are not vast congregations of great Suns, but simply immense gaseous bodies; self-luminous, but in a state

of extreme tenuity, or thinness, and not so distant as formerly supposed. And how has this mighty problem of the physical and chemical constitution of these far-distant and faintly visible bodies been solved? Simply by finding in their spectra, instead of the *dark* lines of the Sun and Stars, the bright lines of gaseous bodies, having foreign substances in combustion in their flames. Thus has this great question, so long agitating the scientific world, at last received a satisfactory answer. Thus again has this small and cheap instrument done for us what no telescope, however large and costly, could accomplish.

So, also, those mysterious bodies, the comets, are found by the spectroscope to be mostly of a gaseous nature, much like the nebulæ, just examined. And how is our acquaintance with these sky-vagrants so suddenly extended, and so intimate? Simply by generally finding in their spectra those same tiny, tell-tale and beautiful bright lines, which so unequivocally declare that they are nothing more than immense worlds of gas.

Another unlooked-for result of spectrum analysis is the determining the character of some, at least, of the meteorites, or shooting stars. By much laborious effort the spectra of a few of these have been caught for a few seconds, but long enough to prove that those examined were *solid* bodies, and that the long yellow trains were produced by the combustion of their sodium. The Moon and planets receiving their light from the Sun can, of course, only give spectra similar to that of the Sun itself, and therefore this science can teach us nothing respecting the chemical constitution of all such mere reflectors of light. We close these articles with a few inferences.

From what has been said it will be readily inferred

that the colour of any particular Star is probably owing to an excess of some one substance in combustion in the vast ocean of flame surrounding it. Thus, if there be an excess of *sodium*, the colour of the Star would be *yellow*; if of *strontium*, a bright *crimson*; if of *silver*, a beautiful *green*, &c.

This science tends, also, to establish the celebrated nebular hypothesis of Herschel and La Place. We would not be understood as saying that it *does actually* establish it, but simply that the weight of this science is on the side of the nebular theory.

If a system of worlds were formed according to this theory, we would naturally expect to find them all essentially of the same constituent elements throughout. And so we find it to-day, so far as respects the Earth and Sun, and many of the Stars, to say nothing of the thousands of fragments constantly falling from the upper regions of the atmosphere to our globe.

Now, as we find such remarkable similarity in the matter of these just enumerated, it is but a rational inference that the other members of our world family —the planets and their satellites—are composed of the same elements.

Such, then, is this wonderful science of Spectrum Analysis. Starting from a most unpromising beginning—a few unattractive, dark lines seen in the solar spectrum—it has grown in importance each succeeding year, as its revelations have been verified, and those mysterious lines were better understood, until those same tiny, unattractive lines have come to awaken a thousand times more interest than was ever excited by Egyptian hieroglyphics on plinth or obelisk. And silently these lines will continue to speak to us, and more and more intelligently and eloquently as we rise higher in the intellectual and moral scale, and thus become better fitted to hold converse with them.

THE WONDERS OF OXYGEN.

There is a substance more widely diffused on our globe than any other known to man. It is called *Oxygen* from the Greek *oxus*, sharp, acid, and *genein*, to generate.

It is found in the Earth, in the water, and in the air, and forms numerous combinations, making substances seemingly of the most opposite character. It is a *simple* substance, that is, not compounded with another, when in its *natural state*. Should the question be asked, "What is Oxygen made of?" the only answer that could be given would be, it is made of Oxygen, as gold is made of gold, silver of silver, iron of iron; in other words, they are substances originally, that is in their *natural state*, existing *alone*. In this they differ from the atmosphere which is a compound of Oxygen and Nitrogen; and from brass, which is composed of copper and zinc. But, more particularly,

WHAT IS OXYGEN?

It is a transparent, colourless, and invisible gas, a little heavier than the air, so that when poured into a vessel, it sinks to the bottom, but soon mixes with the air in it. This gas is remarkable for its affinity with a large number of other substances. By *affinity*

is meant a disposition to unite with other bodies. Thus iron, when unprotected by paint, or some other substance, will soon rust. But *rust* is nothing but oxygen and the iron united, and in chemistry is called an *oxide*. The same effect is seen when nitric acid—aquafortis—which is largely composed of oxygen in combination with nitrogen—comes in contact with iron, or zinc; we then again have oxides, or rusts of iron and of zinc.

But there are some substances with which oxygen will not always unite, when it is in a gaseous state. Thus gold remains untarnished in the air and in most acids, because oxygen in these forms has no tendency to unite with it. The same is true of the metal Platinum. Indeed, this last metal may remain in the strongest nitric acid—aquafortis—for many hours, and its lustre not be even tarnished. In such cases, we say, in chemical language, there is no affinity between the substances.

On the other hand, it has such extraordinary affinity for some bodies, and unites with them with such rapidity, that they are at once dissolved, and intense heat is produced by the violent action. This is true, even of some of the metals, as we shall hereafter explain. This wonderful gas gives such extraordinary power to some of the acids, that they can eat into iron and glass, and entirely destroy them, so that an infant's hand could easily break a large bar of iron or steel, after being subjected to the action of this powerful substance. And when this same gas is combined in proper proportion with hydrogen gas, and the mixture ignited, it produces a heat so intense, that the hardest substances are speedily melted in the pale and seemingly powerless flame.

Strange as it may seem, this same powerful and

destructive substance, *we take into our lungs* at *every breath;* and not only without harm, but with positively beneficial results; nay, it is absolutely indispensable to our life; and were we placed in an atmosphere destitute of this same oxygen, we should immediately die.

More strange still, perhaps—the sparkling fountain that gushes so joyously from the green hill-side, and leaps so gleefully from rock to rock, and which comes so gratefully to our parched lips, this same fountain is composed, almost entirely, of this same terrible destructive agent.

What a striking illustration is it of Divine Wisdom and Power that the *same* substance, by uniting with others, can form such an endless variety of substances so entirely different from each other in character.

Thus water is composed of about 8-9 of oxygen and 1-9 of hydrogen. The atmosphere is made up, in weight, of nearly 1-4 of oxygen and 3-4 of nitrogen; while the solid globe has not far from 1-2 of its contents in the form of oxygen in combination with other matter.

Oxygen forms a part of the hardest and most flinty rocks; and yet it enters in considerable quantity into the composition of butter and oil, and most fatty substances. It enters into the clays; and yet forms a part of our daily bread. It is a constituent of the beautiful flint goblet from which we drink the cooling draught; and yet, as stated, that same cooling draught is chiefly composed of this mysterious oxygen which goes to make up the goblet. It forms the principal part of most acids; and yet it is also found in sugar and in most sweets. It enters into some most bitter and nauseating substances; and at the same time it is found in the most delicious and wholesome food.

It enters largely into the human body and in the bodies of all animals; and yet it is also found in all vegetables and fruits, especially in those of an acid character. It is found in large quantities in intensely black substances, as the per-oxide of manganese; and also in many white, as lime and milk. It is also found in substances that are deadly poisons; and in others that are the antidotes of those very poisons. It forms a part even of our clothing, and of the natural covering of all hairy animals. Such is oxygen. Now, what but Almighty Power could cause a single substance to enter into such a variety of combinations, producing results so startling?

To assert that these combinations are the result of mere accident or chance, is an insult to the human understanding, as well as a gross indignity to the Creator; and one cannot but feel a glow of righteous indignation at such folly and shocking impiety.

It is giving to an imaginary something—really, to *nothing*—giving to *nothing* the attributes of Omnipotence. This is robbing Jehovah of His glory. It is horrible blasphemy.

STARTLING EXPERIMENTS.

With this remarkable substance, some very striking experiments may be performed. Thus steel wire or a watch spring may be burned in this gas, if pure. To make the gas, take about equal quantities of chlorate of potassa and black oxide of manganese and heat in an iron or copper bottle, and the gas can be collected under water. It will be better for those desiring to experiment with this gas, to consult some work on elementary chemistry for directions as to the arrangement of apparatus, as this can be best understood by the engravings in such works, showing the instruments in position.

In this experiment of burning steel, the heat becomes so intense, that the melted metal is thrown in small globules against the sides of the glass vessel, and so high is the temperature of these globules, that they *instantly* melt the glass and bury themselves in it, and often go completely through it. This extraordinary heat is the result of the rapid union of the oxygen with the metal, and being pure gas, there is nothing to hinder an energetic action. This will be found a most brilliant and beautiful experiment. Another remarkable effect of oxygen in producing a high temperature is seen in the manufacture of Bessemer steel. In the bottom of the vessel in the furnace, holding the molten iron, are strong tubes connected with a powerful blowing apparatus operated by steam. The object of this is to introduce into the melted metal, so as to pervade the whole of it, a strong current of air. When this is done, the temperature is raised from 3000 degrees to 6000 in a very short time, and *without any increase of fuel* whatever. Now, how is this remarkable result secured? Simply by the agency of this remarkable gas. The atmosphere as shown contains about 1-9 of oxygen, and this coming everywhere in contact with the melted metal, seizes upon the carbon—that is coal-substance—that is always found more or less in iron in its natural state, and completely consumes it, and thus in the iron itself is found the requisite fuel to obtain such high temperature, while at the same time the metal is thoroughly purified, and common iron converted into steel at a mere nominal cost.

This process gives also a *fibrous* structure to the metal, imparting to it the toughness of wrought iron.

In modern times, no more important use of oxygen has been made in the arts. This single discovery has

already saved hundreds of lives in giving so much additional strength to railroad wheels and axles, and rails, and to machinery generally.

Thus, by a beneficent Providence, is this simple gas made a most valuable servant of man.

Another very beautiful and instructive experiment can be performed by lowering a piece of charcoal, slightly ignited, into a small jar of this gas. The coal will instantly glow with great brilliancy. The same may be varied with a candle just extinguished, having a spark on its wick. The candle will instantly burst into a bright flame with a slight explosion, and the experiment may be repeated until the oxygen is consumed. But far more brilliant results will be obtained by lowering into the gas a small piece of phosphorous in a small metal ladle, the phosphorous being previously ignited. In this experiment the light is too brilliant for the eye to bear without injury; and those with weak eyes should not attempt to witness it without protection of the sight.

Another startling experiment is performed by inhaling the gas—which may be safely done by those of *sound* lungs—and then taking a candle having a large wick, just extinguished, but having a spark remaining, blow a slight puff of the gas directly upon it, and it will instantly burst into a flame. Another person extinguishing the candle, it may be relighted several times by the person having inhaled the gas, producing a startling effect.

One of the most unlooked for results is secured by the use of oxygen in combination with bydrogen; that is, in the use of water upon some of the rare metals. To illustrate: Take a small piece of the metal potassium, size of half a pea—obtained only of some practical chemist—and throw it upon a saucer of water,

and it will instantly burst into a flame, continuing to burn while moving rapidly over the surface, and going out with a slight explosion. The philosophy is this is thus explained. Water is composed of oxygen and hydrogen. The potassium has unusual affinity for oxygen, and unites with it with such violent energy that great heat is evolved. But in this union of the oxygen of the water with the potassium, the hydrogen of that water is set free, and this liberated hydrogen *cannot reunite* with the remaining oxygen, for it is a law of matter that *bodies shall unite in certain definite and unalterable proportions*, and in *none other*. Therefore this invisible, freed hydrogen, being in the immediate vicinity of this heat referred to, is set on fire, and burns with a beautiful violet-coloured flame, as the metal dashes across the surface of the water. The colour of the flame is owing to a *small* portion of the vapour of potassium which is burned with the hydrogen.

It will be seen, therefore, that it is not the *metal*, strictly speaking, that we see burning and producing the flame, but the *water;* or, that part of it we call hydrogen.

Here then is an instance of *actual burning* of *water*, in an experiment which any one can with safety perform.

This last experiment partially explains another, which has often excited great astonishment. I refer to the

LIGHTING OF A CANDLE WITH AN ICICLE.

This feat, always interesting and instructive, is performed by inserting in the upper part of a *large* wick of a candle, a piece of potassium in such a way that it can readily be reached by the ice—the wick

having been previously saturated with spirits of turpentine—and then, on application of the icicle, it will burst into a flame. Some caution is necessary to prevent the escape of the metal, as it may set inflammable bodies on fire.

The philosophy of this is the same; the ice is composed like the water, of oxygen and hydrogen, and the oxygen uniting with the metal, sets free the hydrogen. A drop of water may be used in the absence of ice.

These last experiments are exceedingly and startingly suggestive of future possibilities in the history of our planet. The waters of this globe cover three-fourths of its surface, to say nothing of its subterranean seas and lakes that spread out beneath our feet between us and the dread oceans of liquid fire at a greater depth. The agents are at hand to convert this world of waters into the original elements, and it but requires the Almighty Fiat that these agents may so separate these now combined elements, that they will become at once the most terrible engines of destruction, and the ruin of our globe, and all that is on it, would be complete.

Surely, it is matter for congratulation, that there is a Supreme Director of this, and of all other worlds, and that all these terrible forces of nature are obedient to His will.

OUR FAMILY OF WORLDS.

No. 1.

THE SOLAR SYSTEM.

The science of Astronomy furnishes striking illustrations both of advancing tendencies, and of retrograde possibilities of the human intellect.

The early history of our race gives evidence of considerable knowledge of celestial phenomena, and theories then held, though crude, and embodying much error, contained also many elements of truth. At one time, as we shall see, the *true* theory of the Solar System was taught and then soon rejected, and for more than ten centuries a most complex and absurd theory was received as the true philosophy of the heavens.

This in turn was superseded by the revival of the old and true theory, greatly improved and simplified, since which there has been no relapse into scientific error.

But let us look for a few moments at the early history of Astronomic Science. Josephus informs us that the sons of Seth, the third son of Adam, studied the celestial phenomena, and wrote their observations on two pillars, one of brick, and the other of stone, in order to preserve them from the destruction which Adam had foretold would come upon the world. He also states, that Abraham taught the wisdom

and power of God from the order of nature, an the wonderful influence of the Sun, and from the motions of the Moon and planets, and that he also read lectures both on Astronomy and Arithmetic to the Egyptians, of which sciences they knew nothing until he introduced them from Chaldea into Egypt, and that they afterwards were taught in Greece.

When Alexander took Babylon, his preceptor, Calisthenes, found in that city astronomic records made by the Chaldeans dating back 1903 years before that period, which could be about the time of the confusion of tongues at the tower of Babel, and the dispersion of the human race. It is probable, therefore, that the Chaldeans were among the most ancient students of astronomy. The Chinese have the oldest authentic observations known to be on record. Thus they have recorded a conjunction of five planets at the same time, that is, an apparent meeting of the planets in nearly the same place, which occurred 2461 years before the coming of the divine Redeemer, or, about a 100 years before the flood. The earliest record of a Solar eclipse is preserved by the same remarkable people, which occurred 220 years after the deluge. By the most laborious calculations of some of our astronomers, it has been ascertained that these phenomena actually took place at those remote periods; thus at once verifying the records of the Chinese, and furnishing a most striking illustration of the wide reach and power of mathematical analysis. Among the earlier theories it was taught that the Earth was flat and at rest, and that Sun, Moon, Planets, and Stars all revolved around it. Pythagoras first taught the true theory, that the Sun was the centre of the System, and that our globe and all the planets then known, revolved around it. But it

seems to have been a mere theory, and though true, was, apparently, unsupported by the requisite mathematical evidence, and hence, being at variance, as was supposed, with the evidence of the senses, it soon ceased to be regarded as founded in true philosophy, and was rejected.

Ptolemy, of Alexandria, in the second century of our era, wrote a work called the "Great System," in which he wholly rejected the Pythagorean theory, and maintained that the Earth was the centre of the system, and was at rest, while Sun, Moon, Planets, and Stars all revolved around it. This monstrously absurd system was taught the whole civilised world as true science until the fifteenth century, when Nicholas Copernicus, a native of Thorn, in Polish Prussia, revived the Pythagorean theory and demonstrated its truth so clearly that the Ptolemaic system was speedily overthrown, and men then wondered that a theory so preposterously absurd could have been for a moment entertained.

Ptolemy, however, made many valuable contributions to astronomic science, and was the ablest philosopher of his age. After Copernicus, Tycho Brahe, a distinguished Danish astronomer, greatly advanced the science by his numerous discoveries. But at the close of the 15th century a new impulse was given to this noblest of the sciences, by the remarkable discoveries of Kepler, a German, and Galileo, an Italian. The former discovered the laws of motion, and demonstrated that the orbits of all the planets were not circular, as had hitherto been supposed, but elliptical or oval-shaped; and the latter so improved the telescope that many important discoveries of celestial phenomena were made, as the satellites or moons of Jupiter, and the phases of Venus, thus

greatly strengthening the argument for the Copernican theory. But, strange to say, with all this *ocular* demonstration, ordinarily regarded as so satisfactory, Galileo was most bitterly persecuted hy the Romish church, and compelled to puhlicly renounce his theory of the daily revolution of the Earth on its axis, or sacrifice his life. For this church has ever claimed perfect infallihility in all matters, whether spiritual or philosophical. But every schoolhoy of to-day knows that the Earth turns on its axis every 24 hours. The next great astronomer was that prince of philosophers and mightiest of human intellects, Sir Isaac Newton, the humble and devoted follower of the meek and lowly Redeemer. To this truly great and good man was given the high honour of discovering that suhlime law of universal gravitation, or attraction—that law, which, in its various modifications, gives solidity alike to pebble and planet, and holds pehhle and planet alike in place. This was the dawn of a hrighter day in astronomic science, and from this time forward the advance was most rapid, as the key was now found by Newton's great discovery, that unlocked the doors of the "chamhers of mystery," and made easy the solution of many very difficult problems, which had hitherto vexed the patient souls of many struggling philosophers.

The true system of astronomic science as now held is therefore called the Pythagorean, or, more commonly, the Copernican system. It teaches that the Sun is the great central orb of our family of worlds, and that around him they all revolve at various distances and with different velocities, while the Sun itself is at rest, as respects these various hodies.

This solar system of ours is a group of worlds apart from the Stars, and though seemingly moving among

them, and not far distant from any of them, yet is at an inconceivable distance from the nearest Star.

This will be more fully realised when we remember that the Sun, which, during the summer months, blazes so fiercely in the summer sky, overpowering both man and beast by its intense heat; this Sun, upon whose refulgent splendour no human eye can even for an instant gaze without pain and serious injury to the sight; this Sun, which so brilliantly illuminates not only our globe, but all the other worlds of our family, this same Sun is only a Star, and if placed at the distance of the Stars, not only would it appear as one of them, but if placed at the distance of some of the Stars, not one ray of light from it would reach us; it would not be visible at all, even to the strongest sight. From this it will be seen that our family of worlds is like a collection of particles of dust seen in a darkened chamber floating in the sunbeams, and moving *regularly*, we will suppose, around a larger and brighter particle in the centre, all occupying a space that can be covered by an infant's hand; while the other myriad dust-particles in the room, in the street, in the field, in the *whole* atmosphere surrounding the earth, may faintly represent the starry heavens above, beneath, and around us.

This then is our family of worlds, placed within sight of the Stars, and doubtless feeling their attractive power—though insensibly—but having no *immediate* connection with them, and in no very perceptible way influenced by their presence; but living apart by ourselves, and governed by our own physical laws.

Let us now look at the composition of this wondrous system of worlds, and thus become acquainted with

the members of our own family. And none ought to be ignorant here.

The wonders of this system are so overwhelming; its phenomena so sublime that none can realize how much is lost by ignorance of them, but those best acquainted with these stupendous facts. We shall find in this world-family of ours so many marks of design; so many striking instances of divine wisdom, beneficence and power; so many arrangements evidently made for the benefit of the human race, that we cannot but be convinced—if we are open to conviction —that we are living in a world expressly fitted up for our special comfort and accommodation, and shall no longer hesitate to acknowledge the *continued* supervison of an all-wise and gracious Providence; and in view of it all, with more emphasis than ever before, exclaim :— "the *undevout* astronomer is mad !"

OUR FAMILY OF WORLDS.

No. 2.

THE SOLAR SYSTEM.

We come now to consider the various members of our world-family, and the peculiar characteristics of each. First of all, the incomparably grander and more resplendently glorious than all, is the great central orb—the Sun. As an article has been already devoted exclusively to this wondrous body, it is not necessary here to give more than a brief summary of his amazing proportions, and some of the wonderful phenomena growing out of his relations to the other members of the system.

This great central mass is the controller of all the motions of each one of this congregation of worlds. There is not one of these worlds that is not *every instant* struggling to be free from this controlling power, and striving to fly off in a tangent line—such a line as water describes when thrown from a revolving carriage wheel—and then to continue ever moving in that line, away from the solar orb, out in the fathomless abyss. But all these struggles for liberty are, and ever must be, in vain. There goes out from that mighty globe, in every direction, a mysterious, ceaseless influence, invisible as a spirit, silent as the grave, and yet so potent that it reaches every individual member of this world-family—nay, reaches

every individual atom of each of these worlds, from surface to centre alike, and that mysterious influence seizes these various worlds as with omnipotent grasp as they go rushing, dashing on with frightful speed through the vast, dark solitudes of space, and never for *one instant* relaxes that resistless grasp, but holds them all in place obedient to his sway, and thus compels them all to circle evermore around him, and thus do him reverence as their material lord.

This mysterious influence is called attraction or gravitation.

This superior attraction of the Sun is owing to his vastly superior magnitude over all the other members of the system. His diameter is 856,000 miles, equalling in bulk about 1,260,000 worlds like our own. Were a railroad constructed around the Sun, a car moving at an average speed of twenty miles an hour, would be more than 5400 days in completing the circuit. He is about 740 times larger than *all* the planets and moons of the solar system. From this superior magnitude will be understood his superior attraction over all the rest, as attraction is always in *proportion* to the *quantity* of matter. This then is our family tie; this is what holds us together, and causes all our neighbour worlds, with our own, to cling to and move so constantly around the Sun, while the Sun itself is pursuing his own individual career around the great unknown centre of our sidereal world, requiring more than 18,000,000 of years to complete a single revolution.

This Sun not only thus controls all the members of our world-family, but, as if to compensate us for our allegiance, warms and illuminates them all, and by his mysterious power exerts upon them all an inexplicable electrical, or magnetic, and also a powerful

chemical influence, the effects of which are distinctly seen in all animal and vegetable life, and doubtless, to some extent, affecting even the operations of mind; but how far, and in what way, mental philosophy has not yet been able to determine.

To produce such stupendous results as we annually witness in the vegetable kingdom, especially, and not only on our globe, but on others vastly greater, and at such immense distances, too; to do all this, the Sun must necessarily have within itself mighty energies and vast resources of which we can have but faint conception. Let it be remembered that we are removed from this wonderful source of complicated influences, about 92,000,000 of miles. These mysterious influences travel toward us over this mighty abyss between us and the Sun, at the rate of 182,000 miles per second. How subtle and potent must they be to perform this long journey without losing all their power.

And how tremendous must be the force that can give them such impulse that they never fail nor tarry by the way. As to the mode of operation of this propelling force, we are totally ignorant. We are not then so much surprised when we learn that this source of light, heat, and electrical and chemical influence is a vast globe of either molten, or, white-hot matter, surrounded by an ocean of gas on fire, 50,000 miles deep, and shooting out flames on every side, more than 50,000 miles high, as daily witnessed with suitable apparatus under a clear sky.

We come now to the other members of our family.

It is necessary to state here, that the members of the Solar System are divided into two classes: the Planets, or Primaries, and the Satellites, or Moons called also Secondaries. While the Planets revolve

around the Sun as their common centre, the Satellites, or Secondaries, revolve around their respective Primaries, both moving at different distances and with various velocities.

What is the planet nearest the Sun now known to us? This, until within a few years, has been supposed to be Mercury; but in 1859 M. Lescarbault, a a French physician, asserted that on the 26th of March of that year, he saw distinctly a dark body pass across the Sun's disc, and on the matter being thoroughly investigated by Le Verrier, probably the greatest mathematician of this age, he came to the conclusion that a new planet had been discovered between Mercury and the Sun. On March 20th, 1862, Mr Lummis, of Manchester, saw a similar object pass rapidly across the Sun's face, and several others claim to have witnessed the same phenomenon. It has been named Vulcan. Astronomers, however, are not *all* agreed respecting its existence.

Its distance from the Sun has been estimated to be about 13,000,000 miles; and its time of revolution around the Sun, that is, its year is supposed to be about twenty days. Its seasons, therefore, would have only *five days* for each. It must be borne in mind that the time of revolution of a planet around the Sun, whatever it be, is its *year*, and that of its revolution on its axis, its *day*.

The planet long known as the nearest to the solar centre, is Mercury. On account of its nearness to the Sun, it is difficult to see it, as its light is generally lost in the solar rays.

It is never seen more than 30 degrees from the horizon, which on the sky would appear to be about 30 feet. It is visible occasionally above the Sun in the evening, and is then evening star; and soon after

it is seen preceding the Sun in the morning, and is then morning star. In a good telescope it exhibits all the phases of the Moon, and in the crescent form is a most beautiful object. It revolves around the Sun in 88 of our days. Hence its seasons are only 22 days each; and if there be vegetation there for the support of animal life, that vegetation and life must exist under very different conditions from what we find on our globe. But from its proximity to the Sun, and receiving consequently greater electrical influence, there may be a rapidity in vegetable growth making it equal to that of our longer summers.

While its year is so very brief, its day is about the same as our own.

Its mean—that is average—distance from the Sun is 35,000,000 miles. The orbit of this planet is the most eccentric—that is oval-shaped—of any one of the larger members of the system, so that it is sometimes only 28,000,000 miles from the Sun; and then dashes away in its elliptical or egg-shaped path to the distance of 43,000,000 miles.

Being so near the Sun, the laws of motion require that such a body move very rapidly in its orbit in order to partially overcome the powerful solar attraction, and thus prevent it being actually drawn into that body. Hence we find Mercury rushing through his orbit with the startling velocity of 30 miles a second.

We shall better realise how great is this velocity when we remember that it would carry us aronnd our entire world—25,000 miles—in about thirteen minutes. Hence he moves each hour about 108,000 miles in his path around the Sun. Mercury is about 3,000 miles in diameter. As all spheres are to each other as the cubes of their diameters, this would make

him equal to 1-20 the size of our globe; in other words it would require twenty worlds like Mercury to make one of the volume or size of the Earth, and 25,000,000 to form one equal to the Sun. The matter of this planet is 1-4 denser than the matter of the Earth. As the body is so much smaller than the Earth, its attractive power is proportionately less, so that a stone dropped upon its surface would fall about 7 1-2 feet the first second, while the same body dropped to the Earth's surface would fall about 16 1-2 feet in the same time; because of the greater attractive power of our globe, resulting from its superior mass or weight. So also a body of one pound's weight here, on Mercury would weigh only about seven ounces from the same cause.

It must be borne in mind here that though it would require 20 globes like Mercury to equal the Earth in *volume* or bulk; yet, as the matter of Mercury is more dense or heavier than our own, it would need but 16 such bodies to equal the Earth in *weight*.

When this Planet is at its perihelion, that is nearest the solar centre, the Sun appears seven times larger than to us, and must be a most magnificent object. At the same distance, it receives ten times as much heat from the Sun as we do, and unless protected by a very dense and extensive atmosphere, it could not be inhabited by beings of an organization like our own.

Mercury has evidently been subject to the most tremendous volcanic action, as one mountain at least is ascertained to be ten miles in height, which is about twice the elevation of any known on our globe—Dhawalaghiri of the Himalayas being less than 29,000 feet.

If the planet is inhabited, doubtless the same wonderful adaptation and marks of beneficent design are

seen there, which so abundantly show the hand of a gracious and all-wise Providence in the formation of our world; and whatever may be the temperature at the planet's surface, we may be assured that the physical constitution of all animated creatures there is in such perfect correspondence, that Mercury, with his brief and rapidly changing seasons, and high temperature, is, nevertheless, a delightful residence for them all; for the same all-seeing Eye, and the same infinite Wisdom, and the same almighty Power and wondrous Beneficence that are visible on every hand around us, are enlisted in the ordering and controlling of the affairs of this neighbouring world.

OUR FAMILY OF WORLDS.

No. 3.

The next planet in order from the Sun is Venus, the most beautiful to the *unaided* eye of them all. We say to the "unaided" eye, for there are incomparably more beautiful and wonderful features in some of the other planets, when viewed by large telescopes, as we shall hereafter see. Let it here be borne in mind that all the planets—except a few of the invisible asteroids, or smallest planets—revolve from west to east around the Sun in a given path, *outside* of which they need never be sought. That path is called the *Zodiac*, and is 16 degrees in breadth. The Ecliptic is the *apparent* path of the Sun in the heavens, but in reality it is the path of the Earth, as it pursues its way among the Stars in its annual journey around the Sun. This ecliptic is inclined about 23 1-2 degrees to the equinoctial or equator of the heavens, which is directly over the equator of the Earth. About one-half of the ecliptic, therefore, lies north of the equator, and the other half south of it. Now, through the *centre* of the Zodiac runs this important circle, the ecliptic, so that there are eight degrees on each side of it. This Zodiac then is the *world-path* of our system, where alone we must always seek the planets. It is divided into 12 equal parts of 30 degrees each, called *Signs* of the *Zodiac*.

It will prevent much loss of time and labour, therefore, in seeking for the members of our world family, to bear in mind that the planets seen by the unaided eye can never be found more than eight degrees either north or south of the ecliptic, and that this ecliptic is never more than 23 1-2 degrees either north or south of the equator of the heavens, which is invariably directly over the equator of the Earth. Attention to this will greatly facilitate the finding of planets. When Venus rises *before* the Sun, she is Morning Star, and when *after*, she is Evening Star for about the same length of time.

This planet, like Mercury, exhibits all the phases of the Moon; at one time appearing as a delicate and most beautiful crescent, then a half-moon, then gibbous, or bulging, and then gradually becoming full. After this she passes through a series of changes of an opposite character, gradually waning from the full to the gibbous, then to the half-form, then to the same beautiful, delicate crescent, when it is wholly lost to view in the superior brilliancy of the Sun, which by this time it has seemingly approached. These phases can be distinctly seen with a telescope of about 2 1-2 or three inches diameter, and will amply reward the observer for the time and expense requisite for making the observation. The same glass will also present the Moon under a new and startling aspect, exhibiting the shadows of the lunar mountains, and the craters of the extinct volcanoes with considerable distinctness.

The mean, that is average distance of this planet from the Sun, is about 66,000,000 miles. Her year is about 225 of our days. The day of this planet is very nearly the same as our own, and is therefore commonly reckoned as of 24 hours.

It moves in its orbit around the Sun at the rate of 22 miles a second, or about 79,000 miles each hour; so that while we are gazing at this beautiful and apparently *stationary* body, it is dashing on through space more than 3,000 times faster than a railroad passenger train travelling 25 miles an hour! Her great distance from us causes her to appear stationary.

Venus is about 26,000,000 of miles from the Earth when both bodies are on the *same* side of the Sun; but when the Earth and Venus are on *opposite* sides of the solar centre, then she is about 158,000,000 miles distant from us. This, and her change of position, by which her phases are produced to our view, will explain her varying brilliancy as seen by us, at one time so bright as to be seen at noonday, and casting a distinct shadow at night, at others appearing very much like one of the brighter Stars. She is never seen more than 47 degrees from the Sun, hence cannot be visible more than about three hours before sunrise, or after sunset.

Her diameter is about 7,500 miles, and her volume is therefore about four-fifths that of our planet, while her density is also nearly the same; that is a cubic foot of matter of average weight from Venus would weigh about the same as a cubic foot of matter of average weight of our own globe. A body weighing a pound here would weigh only about five-sixths of a pound there on the planet's equator. It would be well for the reader to fix in his mind here an important principle in estimating the attractive power of different globes; that is, their attractive power upon *bodies on the surface.* To illustrate: This attractive power is not *exactly* in proportion to the *size* of the planet. This will be understood when it is remem-

bered that a body lying upon the surface of a *small* planet feels the attractive power of the *whole mass* more sensibly than on a larger globe, because this body lies *nearer* the *whole mass* than if it were far out from the centre on the immense circumference of a great globe like the Sun; for the law of gravitation is that attraction *decreases* in power as the square of the distance *increases*.

Hence it is that bodies on the Sun, though weighing so much more than they would on the Earth, yet do not weigh as much as they would but for their great distance from a large portion of the Sun's matter. In other words, if the Sun were condensed to one-half his present bulk, bodies would weigh more on his surface, because they would be *nearer* his whole mass of matter.

The Seasons on Venus are very much the same as on Mercury. No Moon has yet been generally observed revolving around this planet, although some astronomers assert that a very minute one has been seen. The planet has doubtless many aerolites moving around it, as has our globe, and one of these may serve as a small Moon.

THE EARTH.

We come now to our own globe, which is next in order of distance from the Sun.

The astronomers of remote times did not include the Earth in the catalogue of planets.

It was regarded as occupying a far more important place in the heavens, or, rather, as not belonging to the heavens at all, strictly speaking, but holding the first rank in the material creation as the great central world around which Sun, Moon, planets and Stars all revolved, while the Earth was firmly and immovably

fixed as a great pivot of motion. The idea of its moving through space was treated as a gross absurdity, and contrary to all the evidence of the senses.

It was argued, and certainly very plausibly, that it was plain that the Sun rose in the east, and passing majestically through the heavens, set in the west.

And further, it was gravely asserted, thus did the Moon, planets, and even all the Stars, and with great regularity, also; and as if all this were not evidence enough, comets occasionally came to add the weight of their testimony to prove the general movement of the heavenly bodies around our globe, while meteors and aerolites, or Shooting Stars all tended to strengthen the conviction of the fixedness of the Earth and the revolutions of the Stars. But this theory was found unsatisfactory and far from sufficient to explain many astronomic phenomena.

For instance, upon what the Earth *rested* was a question that caused the ancients much perplexity and gave rise to many absurd theories. Thus it was at one time taught that it rested upon the back of a huge turtle; at another, it was said to he supported by a great elephant; and by some nations it was asserted to he resting upon the shoulders of an immense hull, and when the animal was weary of holding it upon one shoulder he shifted it to the other, and this was the cause of earthquakes. But upon what the turtle, elephant, and bull rested, their theories did not attempt to explain, and these questions were regarded too deep for their philosophy, as doubtless they were.

It is a most interesting and important fact, that while these ridiculous and childish theories were

seriously maintained by grave philosophers of heathen nations, the *true* theory was, in part at least, taught in the Sacred Scriptures.

Thus, in the book of Job—the oldest book in the world, and written 200 years before the time of Moses, the great truth respecting the Earth's real position is thus explicitly and sublimely announced: "*He stretcheth out* the North over the empty place, *and hangeth the earth upon nothing.*" How came the Bible to be so far *in advance* of the schools of science? How can we explain the fact, that in an age of profound ignorance of the true principles of science these Scriptures taught so clearly, in such striking and sublime language, these two great astronomic truths? First, we have the startling fact, clearly stated, that this globe we inhabit is *not resting upon any support*, but is *floating in space.* Second, the truth of comparatively recent demonstration, and only by the greatest telescopes, that there are but *few stars* in the *northern* part of the heavens, in comparison with those in other parts.

How can we account for this? There is but one way, and that is by admitting that these Scriptures are not the production of *human* minds, but the exclusive work of the Spirit of Jehovah.

For, if the Bible thus early taught science of which the *whole world* was then ignorant, we must conclude that it was written under the immediate direction and at the special dictation of the Divine Spirit, and therefore is indeed the Divine Revelation it claims to be.

The foregoing sublime announcement of the Earth's suspension in space, and consequent regular rotation every 24 hours on its axis, is daily receiving striking confirmation in all the observatories of the world. In

these observatories there are telescopes called *meridian* circles and transit instruments, whose chief work is to note the passing of a star over the meridian line at a given moment. Such is the astounding regularity of their apparent motions, or, more properly, of the motion of the Earth on its axis, that the great astronomer, La Place, stated, that after a most rigorous investigation, he finds the Earth's motion has not changed the *one hundredth part of a second of time* in 2000 years! How perfect are the Creator's works!

The same remarkable regularity marks the annual journey of our globe around the Sun. Let it be remembered that to complete a journey, say of 3,000 miles from Boston to San Francisco, precisely at a *given moment*, there must be numerous *stoppages* in order not to be in *advance* of time, and then a frequent quickening of speed so as not to be *behind* time; but here is this great traveller, the Earth, performing each year a journey of nearly 600,000,000 miles without a variation of *one hundredth part of a second of time*, and doing this not once, twice, or a hundred times only, but for tens of thousands of years, and this two without a single stoppage, or any other than regular rates of speed in given parts of its orbit.

In performing this long journey we dash along at the rate of about 68,000 miles each hour, and the marvel is that we are not left behind, and a still greater marvel is it that the atmosphere, and thin, fleecy clouds are not streaming out in space, and entirely lost to us.

OUR FAMILY OF WORLDS.

No. 4.

In our last we spoke of the daily revolution of the earth on its axis being performed with such extraordinary accuracy that it has not varied *one hundredth part* of a *second* of *time* in 2000 years. It is a question of more than ordinary interest, what *causes* this daily revolution? For there must be some *cause* to produce every *effect;* and thus we find it throughout all nature—cause everywhere precedes effect.

It has been said, that

> "When Earth rolled from God's right hand,
> The primal impulse then was given,"

and that this "primal impulse" has, ever since, kept it thus rolling. But this is the language of poetry, rather than of philosophy. There must be some cause *now, to-day*, operating which produced this most wonderful phenomenon—the daily turning of this huge mass with such amazing regularity, notwithstanding the seeming lopsided form of the globe from the mighty mountains projecting their vast ranges miles out into empty space.

What, then, is the cause of this stupendous result? A theory proposing to explain it has been recently presented, which seems at least deserving of careful consideration, while it is admitted, it does not meet all the difficulties of the case. The theory is this:

The cause of the diurnal revolution of our globe is electricity. To illustrate: Take a straight bar of steel and convert it into a permanent magnet, and having brought the ends to a fine point, arrange it in a *perpendicular* position so that it can revolve with the least possible friction. Then bring a powerful current of electricity to bear upon a point of the magnet about equally distant from the extremities, and the magnet will commence revolving and continue to revolve as long as the electrical current is flowing. Stop the electric current and the revolution of the magnet stops. This magnetic or electric current rushes from the centre to the ends of the magnet, *revolving around* it as it proceeds. Now it is known that the earth is a great magnet. Electrical or magnetic currents are passing constantly over its surface. These currents revolve rapidly around the earth from East to West—the opposite direction in which the globe is turning. These magnetic streams are produced by the heat of the Sun, and also by the chemical influence of his rays. Now as the solar rays fall most directly upon the equatorial and tropical regions, the heat is greatest there, and consequently most electricity is generated there. It must be here understood that the solar rays have immense power to produce electricity. Indeed, any kind of heat, natural or artificial, produces more or less of the magnetic current. This electricity or magnetism generated at the Equator, rushes to the poles of the Earth; not in direct or straight lines, but by an infinite number of *spiral circles around the earth.* These currents never for *one moment* cease their flow, but *night and day alike* continue their gyrations around the whole surface of our planet, and with immense velocity ever tending toward the poles.

Now, just as the circling currents of electricity around the magnet caused it to revolve with such regularity, so, it is affirmed, do the numberless spiral currents of electricity generated by solar heat, cause our globe to turn unceasingly, and with such regularity on its axis. Here, then, is certainly a subject worthy of further investigation.

According to this theory, then, should the Sun cease shining, the Earth would cease revolving, and the most direful consequences would result.

To illustrate: The ocean, now held by the greater centrifugal force at the equator at an elevation of *thirteen miles above the common level*, would immediately return to that level on the cessation of this daily revolution, and would instantly sweep with terrific force over vast sections of the Earth, if indeed it did not submerge *all* but the mountainous regions, and thus the larger part of the human race would be once more destroyed.

Again: Should the sun cease shining, there would be at once a suspension of all those electrical or magnetic forces which now have so much to do with vegetable, and doubtless also with animal, life upon our Planet, and upon all the other Planets that may be inhabited.

If this be the true theory of the diurnal revolution of our globe, it of course will apply to all the other planetary members of our world-family.

But we must patiently wait for further developments before adopting this as the true philosophy of this daily wonder in nature.

While the *whole* globe daily revolves with such marvellous accuracy, all parts of it do not describe circles of equal diameter and circumference, and hence do not revolve with equal rapidity. To illus-

trate: Take an orange, and at equal distances from the stem and blow end draw around it a line; this will represent the equator of the Earth, and the stem the north pole. Then draw around it three or four *parallel* lines at about equal distances from each other, between this equator and the pole. It will readily be seen that these circles are not all of equal diameter, nor of the same circumference. Now, this orange represents the Earth. The equator is the *largest* circle on it, and the inhabitants there travel faster in the daily revolution than do those living farther north; because they move through this *largest* circle in precisely the *same time* that the inhabitants further north move through theirs, which are so much smaller. Thus, a resident on the equator would travel about 1040 miles each hour, while another at the mouth of the St Lawrence would pass over only 450 miles in the same time.

Now this will explain why the Stars seem to move with such unequal velocities through the heavens, for it must be understood that *we* move and not the Stars. Thus, those in the *northern* sky seem to us much slower in their apparent motions than those over the equator. This is because of our part of the Earth moving slower than the Earth does in the equatorial regions.

Again: Were we at the north pole, then the Polar Star would be nearly over our heads, and all the Stars would seem to revolve in circles of different diameters around it. If we were on the equator, then the Pole Star would be seen in the horizon, and the Stars on the equator would be directly over our heads.

WHY WE HAVE A POLE STAR.

As the Earth revolves annually around the sun, the axis of our globe maintains constantly the same posi-

tion, or nearly so, for several centuries; in other words, it is always parallel to itself, and therefore this axis points in one direction, that is, to the pole of the heavens, which is always that point of the sky that would be pierced by the extension of the axis of the Earth. The Star now nearest this pole of the heavens is called the Polar Star; but this Star is not *exactly* at the *true pole*, but about one degree and thirty-three minutes from it in the direction of the pointers, the two outside Stars in the cup of the great Dipper. Hence, it describes a circle around the true pole of three degrees and six minutes diameter. This would make the true pole of the heavens about 18 inches from the so-called Polar Star, measured on the sky toward the two pointers, as stated, in the great Dipper. The Polar Star, therefore, is exactly north only twice in 24 hours, that is when on the meridian *above*, and on the meridian *below* the true pole. Surveyors and navigators must therefore carefully take this into account in all their calculations, as serious errors may else result. When on the meridian it is said to *south*, a term applied to all the heavenly bodies at the moment of crossing the meridian line. We repeat, at such times *only* is the Polar Star exactly north. The time of "*southing*" can generally be learned from a good almanac, and always from the Nautical Almanac.

The present Polar Star will approach to within about a half degree of the true pole in the year 2,095, and then recede from it until Lyra, one of the brightest Stars in the northern sky, and now seen nearly overhead when on the meridian, will be the Polar Star. But twelve thousand five hundred years must elapse before the polar centre will have thus changed.

This change is owing to the fact that the axis of our globe is not, *strictly* speaking, *always* parallel to itself; although it is *apparently* so for several centuries, but is describing a circle in the heavens; that is, the end of the Earth's axis or pole, by means of a "wabbing motion" like that of a top while spinning, is pointing in different directions—just as the axis of the top would if it were extended above the upper part—describing a circle about 47 degrees in diameter.

Hence Lyra, one of the brightest Stars in the northern sky, and about 40 degrees distant from the tail, the *present* Polar Star, will in about 12,500 years be the Polar Star of that age, as already explained.

There is a most interesting fact connected with the nine Pyramids of Gizeh in *Egypt*. On the *north* sides of *six* of these pyramids there are openings extending down into the structure, and all of these openings are at an angle of 26 degrees, so that an observer at the bottom, looking along the line of these passages out upon the sky, would, in *each* instance, see the Star Thuban in the tail of the constellation Draco, or Dragon, which at that date, 2123 before Christ, was the Polar Star. It is generally supposed that these pyramids were built at that age.

Now as *six* of these pyramids at that age are so constructed that this remarkable Star could *then* be seen exactly at the opening of each one of them, it would seem that one object in erecting these wonderful structures was to convey to future generations the information that *Thuban* was *then*—forty centuries ago—the *Polar Star*. Thuban is now about 23 1-2 degrees from the true pole. It must not be supposed, however, that this *Star* has changed its place; but, as before stated, the *pole* of the Earth is describing a circle which requires about 25,000 years

to complete it, and as the pole of the heavens must necessarily change with the pole of the earth, Thuban is not *now* the Pole Star, but will be again in about 21,000 years.

We cannot but be struck with the evidence of divine wisdom and beneficence in this remarkable arrangement respecting the Stars. But for their apparent fixedness in space, no mariner would dare venture out of sight of land. The compass would be comparatively valueless, for, however steadily it might point to the north, there would be no fixed points in the heavens by which to determine latitude and longitude, and thus learn where on the ocean we were, and no one would dare, as now, to launch out upon the trackless deep without these heavenly guides.

OUR FAMILY OF WORLDS.

No. 5.

In our last article we referred to the rapid motion of the Earth on its axis as not perceptible, save by the *apparent* motions of the Stars; and although, if on the equator, we would travel at the rate of 1,040 miles per hour, yet no extraordinary currents of air would be experienced by this rapid motion. Now this was long a source of great perplexity to philosophers. We all know the effect of a violent hurricane or tornado, and how resistless the power of the air when rushing in tempest or whirling in cyclone.

But the rate of speed of the most terrible hurricane is only 100 miles an hour. The more terrible cyclone or whirlwind has a far more rapid motion, which is fully proven by its tremendous force in raising masses of a thousand pounds high into the air, and twisting the largest oaks from their stumps, or wrenching the entire tree from the soil and hurling it to almost incredible distances through the air.

But here is the startling fact, that a man may stand on the equator and travel by the revolution of the Earth not merely as fast as a hurricane, but more than *ten times faster*, and yet be unconscious of any unusual agitation of the air. This, as said, was a source of great perplexity, for it was argued that if the Earth did actually revolve on its axis with such

frightful velocity, then it would carry us through the air with such force that it would be all the same as if the *air itself* moved with that velocity, and we were stationary. And this could not be denied upon the supposition that the air was *stationary* while the Earth revolved. But the air is *not stationary*. It revolves with the Earth, carrying with it the clouds and whatever else may be in it.

This explains why the proposal once made to transport ourselves to different parts of the globe by simply rising in a balloon and waiting until the earth had revolved to bring the point to be visited under us, and then descending, cannot be accomplished. The atmosphere would constantly keep us over or near the place from which we ascended, however long we remained suspended in it. But for this, it would, indeed, be an expeditious mode of reaching places on the same line of latitude with ourselves.

It is a most gracious and striking provision of a merciful Providence, that we cannot do this. Did not the atmosphere revolve with the earth, but remained stationary, then we would be hurled through it with a force that would sweep us and everything on the surface out into space, and the moment we fell again to that surface, we should be instantly caught up by this resistless air, and once more hurled out into space; and so the terrible work would be ever going on, and not only would all animated beings be destroyed, but the very globe itself would be ground down to dust by this constant and violent friction of the air.

Rivers, lakes, seas, and even oceans would be scooped out of their beds, and universal ruin would prevail over the entire face of this now beautiful world. How much is accomplished by this single and

simple arrangement by which the air is made to revolve with the Planet! Here are once more the marks of design, and that design of a most beneficent character, indicating plainly a great Designer.

All this proves very clearly that the atmosphere is a *material* substance, and subject to the laws of gravitation precisely like all other matter.

CAUSE OF TWILIGHT.

Our atmosphere has some peculiar properties, and performs some remarkable services besides enabling us to breathe. It is the great producing cause of the grateful twilight of evening and morning, when the stillness and repose of nature seem to invite us to retire from the noise, and bustle, and strife of the day, and to retire within ourselves, and hold communion with our own thoughts, while we review the actions of the past hours, and sit in judgment upon our *motives* as well as our acts. There is a mysterious influence in the twilight tending to produce this sober, thoughtful state of mind so peculiarly favourable to serious reflection. Hence, "Isaac went out to meditate at eventide." And it is but a just inference, from this well-known effect of the twilight hour, that one design of it was to lead us to a thorough self-examination of the thoughts, motives, and acts of the day past.

But how is this grateful twilight produced? We answer, through the *refractive* and reflective power of the atmosphere. But this requires explanation.

It is a principle in the science of optics, or the laws of light, that when a ray of light leaves one medium to pass through another more dense, it is *refracted*, that is, bent out of its regular course. For instance, if we plunge a rod into the water, the rod appears

broken; but this is owing to the ray of light passing from the air into the denser medium of water. Again, if we place a coin in the bottom of an empty basin, and then remove from it, so that the coin is barely out of sight, and then let another pour water into the basin so as not to displace the coin, it will come into view to the first party simply because the water refracts the ray of light. If the water be removed the coin will disappear. Now the atmosphere has this refractive power, and though not so great as that of water, yet it is sufficient to divert the ray of light from its direct course, when that ray comes from a less dense medium. Our atmosphere is supposed to extend only about fifty miles from the Earth's surface, beyond which, if there is any air, it is so rarified—that is, so thin—that it has but little, if any power to refract the rays of light.

Beyond the regions of the atmosphere there is nothing but vacant space, or, perhaps, an exceedingly thin fluid, which, for the sake of distinguishing it by some name, is called *Ether*, but what this is no one knows, nor is it fully known that there is anything whatever in the mighty spaces between us and other worlds; that is, *outside* of our atmosphere.

Now when a ray of light leaves the Sun, it comes in a *straight* line until it strikes our atmosphere, and then, if it strikes it *obliquely*, that is, in a slanting direction, it is bent out of its course. To illustrate: let us suppose it is daybreak. The Sun at that time is several degrees below the horizon, and, as his rays strike our atmosphere, instead of going straight on high over our heads, they are bent *downward* to the Earth, and hence afford us a faint light. As the Sun rises nearer the horizon, these rays of light are in greater number, and more and more bent downward,

giving us still more light, until the Sun itself seems to rise. We say, *seems* to rise, for when the Sun is seen just resting on the edge of the horison, it is in reality *below* it, and it is only his *image* that we see *bent down* to us hy the refractive power of the atmosphere.

The Sun itself is at that moment 33 minutes of arc or space—which is equal to three minutes of time—below the horizon, and if by any means all the atmosphere could be in an instant destroyed, the Sun would, *in an instant*, drop out of sight. The same is true of the Moon, Planets, and all the Stars—all actually *below* the horizon when we seem to see them just resting upon it.

While some Dutch navigators were in the Arctic regions where the night is about four months long, they were agreeably surprised to find the Sun rising 17 days before the regular time. But this premature sunrise was wholly due to an extraordinary refraction of the Sun's rays, caused hy an unusual degree of cold, hy which the atmosphere was condensed to an extraordinary degree, thus increasing its refractive power; as the more *dense* the medium, the greater the capacity of refracting light. It was estimated that while the sun was thus apparently seen above the horizon, it was actually five degrees helow it.

Now all this occurs at sunset precisely as at sunrise, but in reverse order. As the Sun is seen resting on the edge of the horizon, it has actually set, and is below this horizon 33 minutes of arc, that is, space measured on a circle of the heavens, being equal, as stated, to about three minutes of time. This also is true of all the heavenly hodies—all having actually set when they are seen just above the horizon. By this refractive power of the air the day is lengthened

about six minutes, three minutes in the morning and the same at evening.

But twilight is not produced by refraction alone. Reflection has even more to do with it. This, too, requires explanation. When we admit a beam of light into a dark room we see the particles of dust distinctly shining; in other words, they reflect the light falling upon them. This is just what is done by each particle of the atmosphere; for it must be borne in mind that the air is matter as truly as iron or stone. When, therefore, the upper regions of the air are illuminated by the rising or setting Sun, then these illuminated portions reflect their light to those below—more and more faintly at sunset, and more and more brightly at sunrise, and thus by these two agencies we have our delightful twilight twice each day, lasting with us about an hour each time.

But in the Arctic regions the twilight is constant, as the Sun is never more than 18 degrees below the horizon there. Were it not for this reflective power of the atmosphere we should not be able to see objects at midday, save as they were in the direction of the Sun. The Sun itself would be seen only as a great fiery globe in the heavens, while the sky all around would be intensely black, and the stars be visible at noon, but the beautiful blue heavens would never be seen; while in our dwellings and everywhere, and at all hours of the day, we should need the light of lamp and candle even in treading an oft-trodden path. How much then depends upon these invisible particles of air reflecting and scattering this inestimable but incomprehensible something which we call light. But for it the beauties of the landscape, the lovely tints of the flowers, and the bright plumage of the birds would all be lost to us,

and earth be robbed of all its loveliness. Indeed, without refraction and reflection our planet would scarcely be habitable for us with our present organization. Hence, as recorded in the Inspired Volume, among the first acts of Omnipotence in this creation was the command, "Let there be light, and there was light." Here once more we see the marks of an Omnipotent and Beneficent Hand arranging all things for the good and enjoyment of our race. Let the beautiful light lead us nearer its Great Source, with grateful adoring hearts.

OUR FAMILY OF WORLDS.

No. 6.

In our last two articles we referred to various phenomena of Earth. We proceed now with the presentation of other members of our world-family, and shall discuss the wonderful facts in connection with Eclipses, Tides, Aurora Borealis, Seasons, &c., after completing the survey of the Solar System. The next Planet in order from the Sun after our own is

MARS, THE GOD OF WAR,

so called from his fiery aspect. His lurid appearance is attributed to various causes. By some astronomers it is ascribed to its dense atmosphere and heavy clouds. By others to its soil being of an ochery nature, giving it a reddish yellow hue; while others refer it to its vegetation, and suppose the *predominant* colour of its trees and plants is red instead of green. The increased brightness at its polar regions is clearly discernible in winter, owing to the great accumulations of snow in those high latitudes, while during the summer months of those regions the brilliancy is diminished as the snow disappears.

The surface of this Planet is in striking contrast with our own. The Earth has about three-fourths of its surface covered by vast oceans; but on Mars there are only lakes and small seas, and these not in great number, so that the land rather predominates.

Its appearance to us changes very much every two years, when it comes into opposition with the Sun, and is then only 50,000,000 miles from us, and shines almost as brightly as Jupiter, and is often mistaken for some other bright Planet. At other times it is 240,000,000 miles distant, and then appears 25 times smaller to us.

Its mean distance from the Sun is about 140,000,000 miles. Its day is about 40 minutes longer than ours, and its year is equal to 687 of our days, or nearly two of our years. It moves in its orbit at the rate of 55,000 miles an hour.

The diameter of Mars is about 5,000 miles, and it is therefore about one-fourth the bulk of the Earth. Its density, however, is only one-half as great as that of our Planet, so that a stone dropped on the surface of Mars would fall only five feet the first second, because the *whole weight* of this Planet is only one-eighth of the Earth's. The same stone let fall to the Earth would pass through 16 1-2 feet the first second of time, because of the Earth's greater mass and consequent greater attractive power.

Mars has no moon. Our globe presents to the inhabitants of this Planet a most beautiful aspect, going through all the phases that Venus does to us, but appearing larger.

ASTEROIDS.

The next in order of distance from the Sun come *The Asteroids*, or star-like worlds; called also, more properly, *Planetoids*, from their greater resemblance to the planets. These are numerous, very small bodies revolving around the Sun at a mean distance of about 250,000,000 miles between the orbits of Mars and Jupiter. Their periods of revolution are about 4 1-2 years.

These are the only planets that pass *outside* of the zodiac, that is the belt eight degrees on each side of the ecliptic. These planets, in some instances, are so small, that it has been said, "a good walker could easily make the tour of one in a day." The largest, Pallas, has a diameter of about 600 miles, and some of the smaller less than 30 miles.

NUMBER OF ASTEROIDS.

There are now, November, 1875, discovered of these remarkable bodies 146, and Leverrier, the great French astronomer, affirms that there may be 150,000 in all. There certainly seems to be no reason why a large number may not be added to those already known, especially when their supposed

ORIGIN

is considered. A favourite hypothesis with many astronomers has been, that these asteroidal planets are the fragments of an immense world that by some mighty internal convulsion was rent asunder; or, perhaps, dashed into hundreds of thousands of fragments by a collision with some huge comet while rushing wildly through space.

This theory, however, is not favoured by Leverrier, who contends that these minor worlds were formed precisely as were the others of the larger class, that is, by the collecting and condensing of matter at various centres of aggregation. The large number of meteoric masses continually falling to our planet, certainly favours the supposition of large additions of this class to our family of worlds. They travel in a much wider path than do the larger planets—having for a celestial roadway a zone, or belt, 100,000,000 of miles wide.

JUPITER.

We come next to the largest member of our Solar family—the "King Planet"—Jupiter. This truly magnificent orb is estimated to be equal in hulk to 1,400 worlds like our own.

This planet, with Mercury, Venus, Mars, and Saturn were the only members of the solar system known to the ancients.

In the time of Pliny, Jupiter was regarded as the cause of lightning, and in earlier ages it was considered the chief cause of hurricanes and all violent tempests.

Jupiter revolves around the Sun at the mean distance of 475,000,000 miles. Hence the diameter of his orhit is 950.000,000 miles. He requires twelve of our years to make one of his own, that is, to complete one revolution around the Sun. The character of his orbit is a striking illustration of the infinite wisdom that planned the universe, and now directs the motions of each planet and satellite. Thus we find that this vast orhit is not so very elliptical, or oval-shaped as are the orbits of some of the smaller planets, but is more nearly circular. This is rendered necessary hy his immense mass, as so large a hody would be in danger of dashing out into space away from the Sun, never more to return to it, were its path so very elliptical, or oval-shaped as to remove it to a great distance from the Sun in any part of its orhit. As the axis of Jupiter is perpendicular to the plane of its orhit, in other words, not inclined as is our own axis, he has no varying seasons in the same latitude as we have them, but at the tropics, it is perpetual summer; at the temperate zone, perpetual spring; and at *both* poles, perpetual winter.

This monster world has a diameter of 88,000 miles, and therefore, has a bulk not only equal to 1,400 globes like the earth, but is larger in volume than all the other planetary members of our system combined. Were it as near to us as the Moon, it would appear 1,200 times larger than does our queen of night. Notwithstanding its immense size, it revolves on its axis in about ten hours. Hence an inhabitant of the equator of Jupiter, would be carried around by this daily rapid revolution 467 miles each minute. The equatorial inhabitants of our planet are carried only 17 miles in the same time. In consequence of this rapid motion, the centrifugal force on Jupiter is vastly greater than on the Earth, which tends very much to lessen the weight of bodies on its surface, by a far greater centrifugal force than is exerted on any other planet.

This rapid motion fully explains a remarkable feature of this planet—the great difference in its equatorial and polar diameters. While the Earth measures but 26 miles more through the equator than through the poles, Jupiter's equatorial diameter is 5,000 miles greater than its polar.

How are we to account for this extraordinary flattening of this huge world at its poles? This remarkable fact can be explained only upon the hypothesis that Jupiter, like the Earth, was once in a partially liquid state by the action of intense heat; in other words, this mighty mass was once a globe of liquid fire, or a molten mass of far higher temperature than the melted iron of a furnace. While in this state it was revolving, as now, with such amazing swiftness that it turned once on its axis in ten hours, giving to all its matter on the surface an extraordinary tendency to fly toward the equator, as there was the

most rapid motion, and consequently, the greatest centrifugal force, as already shown in a former article; and as this rapid revolution was continuous, the planet cooled down with this accumulation of matter at its equator. The oceans of Jupiter, therefore, are heaped up at his equator to the enormous height of 2,500 miles! What an instance of Almighty Power is here furnished!—a *mountain of water* towering heavenward to the astounding elevation of 2,500 miles, and this amazing phenomenon seen around the whole mighty circumference of 264,000,000 of miles, wherever an ocean in its equatorial regions is found! And this vast ocean is ever kept thus elevated by the simple agency of a centrifugal force. Such a spectacle gives us an overwhelming conception of the power of Omnipotence in making dumb matter thus obedient to his will, and accomplishing such stupendous results. It must not be supposed, however, that the water is 2,500 miles *deep*, but that it is thus elevated above the common level of other zones.

This fact of a difference in diameters proportionate to the velocity of revolution, proves that Jupiter was moulded and fashioned according to the same general laws that operated in the formation of our own world. Although, while gazing at this magnificent planet, he seems to be stationary, yet this huge mass of matter, equal to 1,400 worlds like our own all rolled into one, is dashing on through dark, vacant space at the rate of 500 miles each minute, or 30,000 miles each hour; but such is his enormous distance that this rapid flight is perceptible to us only by the most delicate measurements. How frightful must be the consequences of a collision with such a body!

FOUR MOONS.

This beautiful planet is favoured with four moons, which revolve around him as does our moon around us, undergoing eclipses, and presenting in the Jovian sky all the phases that we see in our moon. These moons can be seen with a good two-inch telescope. The inhabitants of this planet frequently witness two or three, and sometimes, perhaps, even four lunar eclipses all going on at the same time, presenting such splendours of the sky as must ever be unknown to us.

The eclipses of these moons of Jupiter furnished the means of discovering the velocity of light, which will be fully explained in our next article, together with the wonderful features of Saturn, the most remarkable of all the planets of our system.

OUR FAMILY OF WORLDS.

No. 7.

In our last article we promised to refer in this to the eclipses of the Satellites of Jupiter in connection with the discovery of the velocity of light. This truly wonderful phenomenon—the velocity of light—was unknown to the old astronomers. They supposed that light was not progressive, but instantaneous. Hence, the eclipses of Jupiter being all calculated upon the hypothesis that light required *no time* to transmit itself through space, were always occurring either too soon, or, too late, to correspond with the time calculated. This for a long time was a source of vexatious perplexity. In 1617, Rœmer, a Danish astronomer, discovered that the eclipses were always eight and a quarter minutes too early when the Earth and Jupiter were on the same side of the Sun, or nearest to each other; and eight and a quarter minutes too late by the computed time, when the Earth and Jupiter were on opposite sides of the Sun, or farthest apart. From this he deduced the new and startling conclusion, that the continual and vexatious error of calculation was owing to taking no account of the time light required to travel across the orbit of the Earth, and that this time was about sixteen and one-half minutes, and therefore light was about eight and one-quarter minutes in reaching us from the Sun,

travelling with the inconceivable velocity of about 182,000 miles each second. At this rate, light would pass around the Earth (25,000 miles) more than seven times each second. Thus was first discovered the velocity of light; but other methods have since been devised.

One of the Moons of Jupiter, the nearest to the planet, revolves around him in one and three-quarter days; that is, its month, or moonth is one and three-quarter of our days, and in this time it passes through all the phases of our moon.

The outside or farthest Moon completes his month in less than twenty of our days.

The two intermediate Moons have months of about three and one-half and seven and one-half of our days. From this it will be seen that lunar eclipses must be very frequent on Jupiter; and it is estimated that in the course of its year—which is equal to twelve of ours—there are no less than 4,500 eclipses of these Moons; and also nearly the same number of eclipses of the Sun. From the frequency of these phenomena, they cannot excite the same interest there as do eclipses here, supposing there are intelligent observers of them.

It is here again worthy of notice, how admirably the motions of these Moons are adapted to their peculiar positions. The first Moon is about as distant from the planet as is our Moon from us; that is, 240,000 miles. Now when it is remembered that Jupiter is 1,400 times larger than our globe (though his average density is only about one-fifth), we see at once how powerful is the attraction of the huge planet upon the nearest satellite. Were such an attraction exerted on our Moon by the Earth, it would soon be seen dashing down upon us crushing in the

crust of the Earth by the tremendous blow, and letting out the internal liquid fires—the molten matter of the inner world, to overwhelm the entire surface, in one universal and fiery deluge. But this tremendous attractive power is *constantly* exerted upon the nearest Moon of Jupiter without any disastrous results. How is this peril averted? Simply by giving to this satellite so rapid a motion, that its centrifugal force—flying-from-the-centre force—overcomes the great centripetal, or drawing-to-the-centre force of the mighty world around which it revolves. Here again we see the footprints of a Supreme Intelligence.

But we pass to the most wonderful planet of our world-family,

SATURN,

in the Roman mythology, the god of time. To the unaided eye, this planet offers nothing of special interest, appearing only as a star of the first or second magnitude. It will be remembered that the visible stars are divided into six classes according to their brilliancy; the brightest being ranked as stars of the first magnitude, and those only just discernible by the unassisted eye, as the sixth. But when we view this unattractive object with a superior telescope, a most magnificent sight bursts upon our view. There, standing out distinctly before us, is a ribbed ball of light, girted with numerous belts, rivalling in size and splendour the full-orbed Moon of Earth. Around this ball of light, and detached from it, are distinctly seen three, and by some five, luminous, concentric rings, one of which shines with greater splendour than even the ball or planet itself; while at various distances, and moving with different velocities are eight

satellites, or Moons, ever circling around and outside of both planet and rings, undergoing frequent eclipses, and doubtless, to near outside observers, making numerous transits across the planet's disk, or face.

This huge planet has a diameter of about 72,000 miles, and is therefore at least 750 times larger in volume, or bulk, than the Earth. It is not, however, as much *heavier* than our globe, as its matter is less dense than the matter of the Earth, being as *a whole* only about as heavy as pine wood. Hence, the weight of bodies on Saturn would not be much greater than on the Earth, and a stone let fall to its surface would pass through about seventeen feet in a second ; it being remembered, as stated, that the same stone would fall sixteen and one-half feet to the earth in the same time. Saturn is 872,000,000 miles from the Sun, and revolves around it once in twenty-nine and one-half years. Hence it has a polar day of about fifteen years, and a polar night of the same duration.

RINGS REVOLVE.

While this immense body revolves on its axis in about ten and a half hours, making its day less than half of ours, the rings revolve around the planet in the same time, so that the same parts of the ring always remain over the same place of the planet. These rings are all in the same plane, that is, if laid as they *now are* on a *flat* surface they would all touch that surface throughout their whole circumferences. They are placed exactly over the equator of the planet.

The *inside* edge of the innermost luminous ring is about 20,000 miles from the planet, and the outside diameter of the outer ring is about 175,000 miles. The breadth of the *luminous* part of the rings—which is all that is seen save in the most powerful telescopes

—is about 30,000 miles. The thickness of these rings is greatly disproportionate to their breadths, being only about 100 miles. This is the natural result of the tremendous centrifugal force to which they are subjected, which tends to flatten them.

Within the luminous ring and 10,150 miles from the planet, there is a comparatively dark ring, barely visible in the most powerful instruments, and what is very remarkable, sufficiently transparent to reveal the planet itself through it when in certain positions. It has been supposed that this comparatively dark ring is composed of water, and that it retains its ring form unbroken by its wonderfully rapid revolution around the axis of the planet, that is in 10 1-2 hours.

The possibility of a ring of water remaining thus unbroken is fully and easily demonstrated by the experiment already referred to, of a bucket, having a small quantity of water in it, being made to revolve rapidly, when the water will assume and retain the annular, or ring form, so long as the rapid revolution continues. But a most worderful feature of these rings is their constitution. From various phenomena it has been inferred that they are made up of an infinite number of fragments of solid matter, held together by attraction alone, as they whirl round the great orb in their centre, and that therefore they are not rigid as rings of cemented *solid* earth or rock, but flexible, and gently yielding and bending to any required shape by any special attractive force at a particular point.

These, like the supposed water, or transparent ring, are kept from falling to the surface of the planet by their rapid revolution on their axis as does the planet itself, in 10 1-2 hours.

We know nothing of the character of the planetary

worlds that revolve around other suns, nor shall we here be ever informed. There may be circling around these suns, globes as magnificently attended and surrounded as is this wondrous planet of our system; but in *our* world-family there is nothing that approximates it in grandeur of aspect and majesty of motion. When seen in a powerful telescope, moving so majestically throught the heavens, we look upon it with even more of solemnity and awe than we experience in beholding thunderous Niagara or the towering Alps. No thoughtful observer can thus witness this sublime phenomenon without the profound conviction that here, if nowhere else, is seen the Omnipotent Hand. To see these massive rings of 175,000 miles diameter, suspended and so delicately poised in space; upheld by nothing; whirling around the great orb within them with a velocity on the outer edge of 52,000 miles each hour: each ring ever maintaining the same distance from the others, and all the same distance from the great planet they encircle, while eight attendant satellites move in their various orbits with such regularity, that together, they seem a great time-piece, hung out in the sky to mark the passing hours for observant man. To see all this must awaken not only wonder, but reverence and awe.

And this complex mechanism of planet, rings and satellites, is dashing on through space 21,000 miles each hour, and yet planet, rings and satellites all keep in precisely the same place in this rapid flight. How wonderful is all this! What wisdom and power are demanded to adjust and poise these wondrous rings and keep them uninfluenced by the attraction of the numerous and ever-changing satellites in their ceaseless march around them all! Verily, here is a new

and most startling illustration of contrivance, for which there must have been a Great Contriver planning and operating in that far-off world as carefully as on our own.

OUR FAMILY OF WORLDS.

No. 8.

We have next in order of distance from the Sun, after Saturn, Uranus, frequently called Herschel, in honour of the distinguished astronomer who discovered it, Sir William Herschel.

While engaged in some observations with his great forty-foot telescope, he found among the stars of the constellation Gemini, or the Twins, a small star, which was magnified, and at once concluded that it was not a *star*, as these are never enlarged in size, even in the most powerful telescopes, but only have their brilliancy increased. Hence he inferred, at first, as it was observed to change its position, that it was a comet, but after some month's careful examination he found it to be a planet, the outermost of our system then known to man.

It can be seen by a good strong eye on a moonless night without a telescope, if its position be accurately known, but is not at all likely to attract the attention of the ordinary observer, as many stars are of much superior brilliancy. This is owing to its great distance from the earth. If placed at the distance of the Sun from us, it would appear about twice the size of the magnificent Jupiter, and would present a small disk even to the unaided eye. His

DISTANCE FROM THE SUN

is 1,754,000,000 miles. Its light is therefore about 110 days in reaching us, so that if it should be suddenly annihilated, we should have no knowledge of the fact until after 110 days. Being at such an immense distance from the Sun, it describes an orbit whose circumference is about 5,300,000,000 miles. To complete one revolution through this mighty circle, requires more than 84 of our years, which period is therefore the year of this planet.

For some wise purpose doubtless, but unknown to us, the great Author of the universe has made the axis of this planet to lie in the plane of its orbit. Hence its seasons are not well understood by us, as the Sun would appear to us—if placed on the surface of Uranus—to wind around it in a *spiral* form. This axis is just the opposite in position to that of Jupiter which is nearly *perpendicular* to the plane of its orbit, and hence has no variation of seasons at any one part of the planet, but constant spring at one point and perpetual autumn at another, and so of the rest.

Uranus being so distant from the Sun, receives only about three thousandths of the light and heat that we enjoy; that is if the same laws of light and heat operate there as here. But there may be some atmospheric conditions which may so affect the temperature and also the intensity of light, that the planet may experience as much benefit from the solar rays as we do ourselves.

Three-thousandths of the light we receive would be equal to about 300 full moons, so that the inhabitants of this planet do not suffer from want of light. But the constitution of the occupants of this world is doubtless as perfectly adapted to their peculiar condition as is the organization of the minute ani-

malcule that is found in the Arctic regions, and which dies when transferred to the milder climate of the temperate zone.

THE MOONS OF URANUS

number at least four, and some astronomers affirm that six have been seen. From their great distance we know but little respecting them, save the remarkable fact that they revolve around the planet in a plane nearly perpendicular to the plane of its orbit, and while all the other moons or other worlds known to us revolve from west to east, these revolve from east to west. The

DIAMETER OF URANUS

is about 33,000 miles. Taken as a whole, it is lighter than water, and has about the same density as ice; hence its attractive power is greatly disproportionate to its bulk, and bodies on its surface therefore weigh much less than might at first view of its great diameter be supposed.

NEPTUNE,

or as often called Le Verrier, in honour of one of its discoverers, is the next in distance from the Sun the outermost member of our family of worlds now known to us. It is possible that others still more remote and of equal dimensions may yet be discovered. The discovery of this planet was not by mere accident, as was that of the last, but by the most extraordinary feat of the human intellect known in the whole history of our entire race.

Nothing ever done by man before or since, has so fully developed the wondrous capacity of the human mind, and at the same time shown the wide reach and stupendous power of mathematical analysis.

Let us pause a few moments to notice the history of this truly wonderful performance of the human intellect. It was found that the movements of Uranus were often irregular—now in *advance* of computed time—now *behind* that time; and this was long a cause of great and vexatious perplexity to astronomers, as there was no discoverable cause of these irregularities *within* his orbit. Saturn was always at his post in the heavens to a second, notwithstanding his long journey of 30 years. Not so Uranus. At length two astronomers, both young men, set themselves to the mighty task of discovering the source of these disturbing influences.

One of these was Adams, a distinguished mathematician of Cambridge University; and the other Le Verrier, of Paris. Without any knowledge of the other's purpose, each began about the same time the great undertaking. Herschel and others had for some time felt that the disturbing power was not to be found *within* but *outside* of the orbit of Uranus in the form of another planet; hence his striking language representing this unknown outside planet: "We see it as Columbus saw America from the shores of Spain. Its movements have been felt trembling along the far-reaching line of our analysis with a certainty not much inferior to ocular demonstration." Here was ground of encouragement for the young astronomers in their more than herculean task.

The problem was to find the orbit of this unknown world, and then its place in that orbit. Adams, after two years of exhaustive toil, presented himself with his calculations to Prof. Airy, the Astronomer Royal of England, in October 1845, announcing his great discovery. That gentleman, from some strange

indifference, or want of confidence, gave no attention to the important documents, until Le Verrier, the young French astronomer, submitted a similar statement of his discovery of the same planet, to the French Academy of Sciences at Paris, and he then requested Prof. Challis of Cambridge, to search with his large telescope the part of the heavens indicated by Adams, and then was seen for the first time by mortal eye, the great, outermost member of our world family—Neptune.

This was in the summer of 1846. In September of the same year, Le Verrier, not knowing what Adams had done, wrote to Prof. Galle, of Berlin, requesting him to search for the supposed planet at a point indicated, and he too found the new world that same evening, within one degree of the place designated by the gifted young mathematician.

Now let it be borne in mind, that all this was accomplished by a simple exercise of the reasoning faculty alone, unaided by instruments, until *all* the calculations were complete, and these instruments then used only to *verify* these calculations.

This is, as stated, the most extraordinary achievement of the mind of man, of any age. Out in the depths of space, a world is found to be irregular in its motions.

Two men, without once directing their eye to the heavens, find the cause of these irregularities to be a huge globe of solid matter, so distant that no unaided human eye can see it. They not only find such a body to exist, but they determine its precise locality. They not only point out that locality, but state its speed and motion through space; and not only its speed and motions, but they also give its bulk and diameter; and as if all this were not enough, they

take this yet unseen world, upon which no human eye has ever consciously rested, and place it in the balances, and actually *determine its very weight!* Such an effort of the human mind seems worthy of an Archangel!

DISTANCE FROM THE SUN.

Neptune revolves about the Sun at a mean distance of 2,750,000,000 miles. His year is about 165 of our years, moving at the comparatively slow speed of 12,000 miles an hour. Mercury's motion is 105,000 miles in the same time, as he is so near the Sun; because, but for this rapid speed, it would be soon drawn to the Sun and destroyed in his fiery embrace. But as Neptune is so remote, he is not in such danger, and therefore the All Wise Creator gave to him a slower rate of speed as a more rapid one was not necessary to overcome the Sun's diminished attractive power at that great distance. His diameter is about 37,000 miles, making his bulk about 100 times more than that of the Earth.

It has, as a whole, about the density of water—rather less. It has one moon which revolves around the planet in about six days. We as yet know but little respecting the rotation of this body on its axis, or, the inclination of that axis, and therefore can say nothing respecting its seasons.

If its asis is inclined to the plane of its orbit like our own, then there is at its poles alternately a day and night each of 82 1-2 of our years, so that a polar inhabitant there of the average age of our race, might never see daylight, or, never see the darkness of night.

Such then is our Family of Worlds, numbering to-day (December 1875), 175 members, with the prospect

of the addition of many more. Taken as a whole, it presents one of the most wonderful spectacles of which the human mind can conceive. Here are Vulcan, Mercury, and Venus, within the orbit of the Earth dashing through their orbits with startling velocity as they revolve around the Sun.

Then come the Earth and Moon with their complicated motions—the Moon rushing through space around the Earth, while the Earth steadily pursues its annual course around the great central world—both always maintaining the same distance from each other in given parts of their orbits. Then comes fiery Mars, our next-door neighbour *outside* of our own path, followed by the host of 147 minor worlds called Asteroids and Planetoids, seeming rushing wildly through their broad, ethereal path, as if restive under solar restraint, and yet, each one moving in perfect order in its appointed sphere. Then comes majestic Jupiter with his four queenly attendants, moving like a monarch through space, and they too ever maintaining the same positions in respect to each other, followed by the wonderous Saturn with his mystery of rings and satellites, while on the outskirts are seen Uranus and Neptune with their lunar attendants also; all whirling on their axes—planets, satellites, rings, and all as they go "bowling" along their great highway of the skies, no one encroaching upon the other's sphere, but in perfect harmony and order in which the most searching geometry can detect no violation of physical law.

All this of itself is stupendously grand; but when we remember that in the midst of all these whirling worlds, there is one vastly grander than them all combined, and that this one has itself a motion and a path of its own, independent of all the rest, and is

itself revolving around some far-distant, and as yet scarcely known centre, requiring more than 18,000,000 years to complete one single revolution; and when we recall the amazing fact that in this wondrous flight, it carries along with it our globe and all the other globes of this world-family, and that in this long and rapid journey these complex individual motions of the entire system suffer not the slightest derangement, but each moves on at the same distance from its centre first measured by the Almighty Hand, then are we overwhelmed by the amazing spectacle, and involuntarily exclaim, "Great and marvellous are Thy works, Lord God Almighty."

THE AURORA BOREALIS, OR NORTHERN LIGHTS.

In the autumnal and winter months, and occasionally in the summer, we often see shooting up in the northern sky faint columns of light of every conceivable form, and of various colours. Sometimes these columns are of various heights, somewhat resembling the jagged outlines of huge, inverted icicles stretching around and skirting a considerable part of the horizon. Suddenly, the whole range of columns disappears; then, as suddenly, reappears in different form. In an instant, while we are gazing, the whole array of columns, and pinnacles, and towers shifts to the right or left, leaving all dark where a moment before were such gorgeous splendours.

At another time this beautiful phenomenon appears as a huge semi-circle, or arch of light, and over this arch will soon appear another, and still another, until a series of four or five distinct arches are seen, surmounted by a most beautiful fringing of miniature columns and towers of various colours. Again, in an instant, the whole will shift to the other side of the pole, and then change as suddenly back again to its former position. Not unfrequently these towers and columns extend almost to the zenith—the point in the heavens over our heads—and then again, in a moment, vanish, leaving no trace behind. Immedi-

ately beneath these luminous arches, nine of which are sometimes seen, there is ordinarily, visible before they appear, a darkish hue in the sky, which increases until a dark cloud is seen, *below* which auroral displays are only occasionally witnessed.

This is the general aspect of the phenomenon in our latitude; but, in the Arctic regions, and even in the higher latitudes of the temperate zone, the displays are far more frequent, and also much more beautiful, and often attended with startling sounds and the most brilliant coruscations of light. This dark cloud referred to under the arch of light, grows darker as we go north to a certain latitude, after which it becomes fainter, assuming a grayish tint, and, in very high latitudes, often wearing a violet hue. The arch of light has its apex—highest point—over, or in the line of the *magnetic pole*, which is in 70 degrees north latitude. It will be at once seen that this is not the *geographical*, or *true* pole of the earth; that being at 90 degrees from the equator.

This arch, as we shall hereafter see, often changes its position in an instant from one part of the heavens to another on the opposite side of the true pole, while at other times it will be seen in the east or west, instead of the north.

Explorers of the Arctic regions have given startling accounts of the phenomena there, which, but for the number and respectable character of the narrators, would excite doubt.

Thus, Commodore Peary, when at Melville Island, in lat. 74 1-2 degrees, saw during 27 months, what he describes as beyond all adequate description.

At one time there were sparkling bands, spires of light, pyramids of fire, and shifting figures of endless variety of form dancing across the sky from east to

west, and back again from west to east, while all the colours of the rainbow were distinctly visible in overpowering splendour, mingling among and tinting the multitudinous forms in their airy flight, and so sudden were the changes, that it was almost impossible to determine the moment they occurred.

One remarkable phenomenon was particularly noticeable: while in this latitude—74 1-2 degrees—he saw at the *south* of him the auroral arch distinctly defined.

This was owing to the fact that he was *north* of the Earth's *magnetic* pole, while still *south* of the *geographical* or true pole of the Earth. Maupertius states that in Lapland the sky was sometimes tinged with so deep a red that the constellation Orion looked as if steeped in blood, and so numerous and startling were the moving forms of light across the sky, that the people thought they saw armies engaged in deadly fight, and fiery chariots, and a thousand prodigies.

Another writer has stated that in Siberia, on the confines of the icy sea, the luminous forms appear like spectral armies, and that the hissing, crackling noises of these aerial fireworks so terrify the hunters and dogs that they fall prostrate on the earth, and cannot be induced to move while the raging fiery hosts are passing over their heads.

Between Iceland and the Ferro Islands these continuous flashes of auroral light often make the night as brilliant as the day; "and the heavens there, too, seem to be on fire with flames of red and white light, changing to columns and arches, and at length confounded in a brilliant chaos of cones and pyramids, sheaves and radii, and arrows and globes of fire."

The colours of these various forms are ever changing, not even the same figure retaining the same colour

but a few seconds or minutes at the farthest, and these colours, as stated, representing all the prismatic hues of the rainbow, and sometimes rivalling the Moon in splendour.

At one time *nine auroral banners*, or more properly curtains, were seen suspended in graceful folds from the heavens, gently waving their huge folds like banners in a summer breeze, as they stretched across the winter sky. The *streamers* often present a most magnificent appearance in high latitudes. The sky will often wear a flush of rosy light, while these streamers have a deep *crimson* hue.

On one occasion their bases seemed steeped in blood ; their middle was of an emerald green, and the other parts of a rich golden yellow. At another time these streamers were tinged with red, purple, and green. Nothing can give so vivid a conception of these auroral splendours as seen in Arctic regions as to look over a city, or a forest on a bright, sunshiny day, through a triangular prism of glass, when the decomposition of the rays of light will give the observer more vivid conceptions of the beautiful than ever before enjoyed. Such a prism can be procured from a chandelier manufactory for a few pence, and will richly repay the cost.

CAUSE OF THE AURORA.

We come now to the cause of these most beautiful and wonderful phenomena. And here at the outset we must state that on this subject there is a diversity of opinion.

But there is a very general belief among the most scientific men of the age, that these brilliant exhibitions are the result of *electrical* action. Indeed, there are so many auroral phenomena that can be so closely

imitated in a small way by the aid of philosophical apparatus that we are, perhaps, justified in asserting that electricity is the chief producing cause of them, but by what particular *mode* of *operation* cannot yet be fully determined.

We state first a few facts relating to electricity and magnetism—a modification of electricity—which will better enable us to judge respecting the original cause of these phenomena.

It is well known, as stated in another article, that the Sun produces an immense electrical current, or stream, at least, 12,000 miles broad, which is rushing around our globe without a moment's interruption.

But this electrical current, or, rather, infinite series of currents, move in *spiral* curves and thus all wind their way to the magnetic poles and meet there; hence, it is evident there must be an immense accumulation of the electric fluid at those points.

Now when we accumulate electricity on the prime conductor of an electrical machine, and when so highly charged that it can hold no more, the fluid then escapes into the air, and if properly managed, becomes visible in thus escaping either in the form of a brilliant spark, or of a faint and continuous stream of light. Furthermore, if we nearly exhaust the air from a large glass tube, and then allow the electrical current to pass through this rarified or thin air in the glass tube, the electricity is distinctly seen as a luminous current, and bears a striking resemblance to what is witnessed in the northern lights. From these facts it is inferred that these phenomena are produced by the immense quantity of electricity at the poles escaping into the air.

But still more conclusive proof of the *electrical* origin of these lights is found in the fact that the

magnetic needle is so wonderfully influenced by them. Thus, when the auroral arch is stationary, the needle points steadily toward its apex, or highest point; and when this arch changes its position to the other side of the pole, the needle as suddenly changes its point of direction, and when this arch is sometimes seen in the *west* instead of the *north*, as it is in some parts of Greenland, the needle then points to the *west*. So when Simpson, the English navigator, spent six months at Fort Confidence, in latitude 67 degrees north, he *always* saw the auroral arch in the north-west, and the needle *invariably* pointed in the same direction. Besides this, during any brilliant aurora, the magnetic needle is always more or less agitated. Now as we well know that the needle points in given directions from *electrical influence alone*, we must conclude from these instances of mutual sympathy between it and the auroral arch, that electricity is the *chief*, if not the *sole* cause of the Aurora Borealis.

These beautiful phenomena are visible at widely separated points at the same time. Thus one of great brilliancy was seen in France and Pennsylvania at the same hour. Another that occurred on the 3d of September, 1839, was seen at the Isle of Sky, 57 degrees north latitude; and in Paris, New Haven, Conn., and even in New Orleans, all at the same time.

As we would expect from these views of the *cause* of these luminous appearances there are

AURORA AUSTRALIS, OR SOUTHERN LIGHTS,

equalling in splendour those seen in our hemisphere, and essentially the same in all respects.

The highest of these aurora is estimated to be from 10 to 150, or 200 miles above the surface of the earth.

THE UTILITY

of the aurora will be seen, when we remember that the inhabitants of the higher latitudes have long winter nights of from two to four or five months duration. All this time there is no appearance of the Sun, and these beautiful displays of variegated light will to some extent compensate for the absence of solar lights. Certainly they do take from the long, dark winter much of its gloom, and make a residence there more tolerable, if not cheerful; for it must be remembered that these brilliant illuminations are not merely occasional as here, but far more frequent, and for long periods almost constant, and hence serve as a pleasant substitute for the more genial light of the Sun.

THE WONDERFUL TIDES.

No. 1.

Few phenomena of Earth have excited more wonder, and caused more perplexity, and required more investigation to understand than the tides of the ocean, and few illustrate more strikingly the wisdom, power, and beneficence of Him "who hath measured the waters in the hollow of His hand."

To see this mighty world of waters now surging simultaneously for six hours on the same meridian, in one resistless wave to the west; and then, after remaining at rest for a moment, rushing back in one great tidal current to the east; and then once more surging back for the same time to the west, only to return with the same overwhelming force again to the east; and to do this day after day, and week after week, through thousands of years, with such *regular irregularity*—as we shall hereafter see—may well excite our profound astonishment.

NUMBER OF TIDES.

There are four tides every 24 hours: two ebb tides and two flood tides, each continuing six hours. The *flood* tide is that which comes in from the ocean, and at its *full* is called *high* tide. The *ebb* tide is that which flows *out* to the ocean again, and at the *close* of its outward flow is called *low* tide. Thus there are

two flood, or high tides, and two ebb, or low tides, every 24 hours. There are also two spring tides and two neap tides occurring each month. The *spring* tide is one of extraordinary height; the *neap* tide is one unusually low.

Let us now consider

THE CAUSE OF THE TIDES.

The cause of the tides is found in the attraction of the Sun and Moon upon the waters of the ocean. Although the Sun is equal to 70,000,000 globes like the Moon, it will doubtless surprise many readers to learn that he has only one-third as much influence in producing the tides as the Moon. This is owing to his great distance—92,000,000 of miles, while the Moon is only about 240,000 miles distant from the Earth. Hence, as the power of attraction decreases as the square of the distance increases, it will be understood why the Moon's tidal wave as compared with the Sun's, is as 3 to 1. The Moon, therefore, must be regarded as the chief cause of the tides. Had we no Moon, and did not the Sun attract these waters, then they would remain for ever stationary, save as they were moved by the winds on the surface.

But the Sun and Moon do not always act with equal force in producing the tides; hence they vary greatly in height. Thus, when the Sun is 3,000,000 miles farther from the Earth than at other times, his attractive power is less, and his tidal wave is correspondingly low. The same is true of the Moon. Her distance from us varies 26,000 miles; that is, when in perigee—nearest the Earth, she is that much nearer than when in apogee—farthest from the Earth—and her tidal wave is also correspondingly changed.

High tide is produced at a given place, when the

Moon is directly over that place; or rather on the meridian line of that locality. This is not *strictly* true, as from the *inertia* of the waters, that is their disposition to remain at rest, the Moon's influence is not *immediately* felt upon them, and therefore it has passed over or *beyond* a given point before the waters begin to move, so that the high tide occurs at that point about three hours *after* the Moon has passed over it.

As the Moon thus raises the waters under it, producing *high* tide, it will be seen that they must be drawn from the *sides* of the Earth, one *quarter* of its circumference distant, and therefore there will necessarily be *low* tides at those points.

DIFFERENT KINDS OF TIDES.

When the Sun and Moon are in conjunction, that is, on the *same* side of the Earth, they then act in concert, and we then have the higher tides called the spring tides. The same result follows when the Sun and Moon are in opposition, that is on *opposite* sides of the Earth, as they then also are acting in concert, although at first view it would not appear so; but we have also spring tides when the Moon is in quadrature, that is, one-quarter of its circle or orbit distant from the Sun, as when on the meridian at sunset, then the Sun and Moon act in opposition to each other in producing the tides, and the result is a very low tide called neap tide.

But the highest tides of all occur when the Sun is on the Equinoctial line, and the Moon also near it, and thus almost in a line with the Sun. At such times they act more directly in concert, and when the winds are favourable, an extraordinary tide is seen, sometimes doing considerable damage by its great overflow.

It must not be supposed that because the Moon exerts the greatest influence in producing the tides, that therefore its attractive power is greater than that of the Sun. As a *whole*, the great Solar orb exerts a vastly more potent force in attracting the Earth, hut the Moon heing so much nearer is thus enabled to effect far more in producing these wonderful phenomena than the Sun.

TIDES ON OPPOSITE SIDES OF EARTH.

We must here hear in mind, that it is the *difference* of the Moon's attraction that produces tides on the *opposite* sides of the Earth at the *same* time. But this requires explanation. It is easy to understand how the Moon draws up the waters of the ocean directly under her, hut not so easy to comprehend how it should be done on the opposite side. We will endeavour to make this plain. It will he remembered that attraction decreases in power, as the square of the distance increases. Now according to this principle, there will he *less* attraction exerted hy the Moon on the waters on the *opposite* side of the Earth, because they are more distant. The solid globe is drawn in a body and must move as a *whole* toward the Moon. Not so the waters on the opposite side of the Earth. They are at liberty to *lag behind*, as they are not so near the Moon and therefore not so strongly attracted by her; and they *do* thus lag, and hence are elongated like a drop of water suspended from the finger, and thus is produced a high tide where, seemingly, there is no adequate cause, and where, apparently, it is altogether impossible.

In one case, as the tide nearest the Moon, the *water is drawn from the Earth;* in the other, as the tide on the side farthest from it, *the Earth is drawn from the water.*

There is a secondary cause of the tide on the side of the Earth most distant from the Moon. To explain this, it must be understood that while the Moon revolves around the Earth, the Earth in a limited sense, revolves around the Moon, because the Moon attracts the Earth as truly, though not as powerfully, as the Earth attracts that body. Hence, the Moon must have a centre of gravity around which the Earth revolves.

This centre of gravity is estimated to be about 2,000 miles from the Earth's surface toward the Moon. Therefore with each revolution of the Moon around the Earth, there is one revolution of the Earth around this centre of gravitation. The effect of this would be to create a *centrifugal* force on the side of the Earth farthest from the Moon, which would tend to throw off the waters, and thus contribute somewhat to raise higher the tide there. This *swinging off* of the waters from that side of our globe, may be illustrated by immersing the hand in water and then moving it rapidly through space, when the water will collect in elongated drops at the fingers' ends, if not thrown entirely off by the rapid motion.

But this cannot very greatly contribute to this tide at our antipodes; the *chief* cause is the *difference* of the Moon's attraction on the near and farther side of our planet, by which, as stated, the *Earth is drawn from the waters*, leaving them behind in one huge, elongated drop.

WHY THE TIDES OCCUR LATER EACH DAY.

As the Moon revolves around the earth from west to east, she advances eastwardly in her orbit about 13 degrees every 24 hours. Hence, when any part of the Earth, in its revolution, comes under a part of the heavens where the Moon was the evening before,

the Moon is not there, but has gone eastward 13 degrees, and therefore the Earth must turn on its axis as much longer as is necessary to bring that part again under the Moon, which requires generally, not always, about 50 minutes.

The same thing occurs the next evening, and the evening after, and thus the Moon rises, most of the year, about 50 minutes later each day. Now as the tides are produced mainly by the Moon it will at once be seen from this eastward movement and this later rising each day, why they must occur about 50 minutes later each succeeding day.

An exception to this is the Harvest Moon, which will be elsewhere noticed. While the lunar tide is thus daily lagging, the solar tide always occurs at the same time. Hence these two tides always begin to separate after New Moon, being farther apart each day until they again coincide at full Moon, when there is, as already stated, a higher tide than usual, called spring tide.

Then again they separate, until New Moon occurs, when they once more unite, producing another spring tide.

It must not be supposed that the *whole* body of the ocean to its profoundest depths, is *equally* moved by the tides. The tides are mainly *superficial*, and except where the water is of a moderate depth, the *lowest* parts are only slightly disturbed, but to what depth the tidal current extends can never, perhaps, be satisfactorily determined. The Gulf Stream is about three thousand feet deep, having for its bottom a bed of colder water of various depths; but as this stream is the result of other causes than those that produce the tides, it is not safe to estimate the depth of the tidal currents by its own.

THE WONDERFUL TIDES.

No. 2.

In our last article on the tides we stated their number, and explained their cause with other attendant phenomena. We proceed now to notice the remarkable variations in the height of tides in different places, with the cause of such difference.

The tides are greatly affected by *local* causes.

In the open ocean there is comparatively hut little elevation of the tidal wave. This is more particularly observable in the Pacific, where the water rises only about a single foot. But, where the waters are obstructed in their flow, they always more or less accumulate, producing a high tide according to the character of the obstruction.

Thus where there is only a narrow opening to the ocean, allowing but little space for the passage of the waters, there is only a moderate tide. This is fully illustrated in New York bay. The Narrows are so contracted that sufficient water cannot enter the bay in time to produce an ordinary tide higher than three feet. The spring tide, however, is about five feet. At Boston, where the geographical features are more favourable for the accumulation of the waters, the tides are generally almost twice as high. New Haven has also a higher tide than New York for the same reason; the waters rising there to about eight feet.

So at Charleston, S.C., the formation of the surrounding country is such as to produce a tide of about six feet.

But the most extraordinary instance of tidal elevation now known is at Cumberland, situated at the head of the Bay of Fundy.

The formation of this bay is funnel-shaped, and peculiarly favourable for high tides, and hence we there see the water rising to the astounding height of from sixty to seventy feet. The effects of this remarkable elevation are sometimes terrific. The waters roll in with irresistible force and frightful roar—a mighty, watery wall--ever falling, and yet never prostrate, until its force is spent—dashing on with a velocity sufficient to overtake the fleet-footed traveller and the luckless beast that has failed to note its coming, and burying them both beneath its mountain wave.

Ordinarily, the swine that resort to the beach in search of mussels, hear the roar of the approaching tide while yet miles distant, and instantly, with a snort, as a signal of alarm to the rest, they, with wonderous instinct, start at full speed for some elevated site beyond its reach.

It will at once be seen that the power of such a vast body of water rushing on with such tremendous force, must, in the lapse of ages, work important changes along the line of its march, in cutting down elevations and opening new passages for its flow, and thus materially changing the face of the Earth.

These tidal waves are constantly changing the aspect of rivers, as they set up against their currents, and often give to a shallow stream a channel of sufficient depth to float the largest steamer.

The great tide-waves proceed from east to west,

and therefore are arrested by the continents. As a consequence of this the waters on the *east* side of these continents are always higher than on their western, as they are necessarily accumulated and held there.

Thus, in the Gulf of Mexico, and in the Caribbean sea, the water is twenty feet higher than in the Pacific ocean, the waters being arrested by the Isthmus of Panama. The same remarkable elevation is seen in the Red Sea, where the great tidal wave is again arrested by the Isthmus of Suez, and as a result the water is higher there by thirty feet than in the Mediterranean, only a few miles distant on the other side.

Inland seas and large lakes have no perceptible tides, as the *whole* body of water is affected at once, and therefore there is no sensible elevation at any one point. If, however, the whole mass of such a body of water could be weighed when the Moon is directly over it, it would be found to weigh less than when from under the Moon's direct attraction.

BENEFICENT INFLUENCE OF TIDES.

The influence of the tides is far greater than generally supposed and of a most beneficent character. Were the whole mass of the waters to be forever undisturbed, either by wind or tide, they would become putrid, and thus be a vast storehouse of the most pestilential vapours. But it has been so arranged that by this ceasless agitation they are kept pure, and also tend to purify the atmosphere by contact with it.

The uplifted and white-crested waves, falling in graceful curves, are ever washing out of the atmosphere its impurities, and sending it to the land more fit for the use of man; while the great tidal waves

rush up the shallow rivers, and render them navigable, and thus make great cities more accesible to the commercial world.

Thus the Moon not only gives us her mild and grateful light, to rob the night of its gloom, and make it a season of delightful rest, and peculiarly favourable for serious contemplation, but also performs this most important service of sending the waters of the great ocean into every bay, and cove, and inlet on the face of the Earth to take up all the accumulated impurities, and convey them out into the mighty deep. How wonderful that *one* cause, and that so remote, can perform for us so many important offices! There, out in the dark solitudes of space, is a comparatively small, rough-faced globular mass, 240,000 miles from us, seemingly powerless to affect us in any way, save in that of giving us its borrowed light; and yet that same rough-faced globe reaches down her invisible hand, and as it were, with her open palm, in effect, thrusts aside the vast mass of waters for six consecutive hours; and thus continues to do with undiminished power through thousands of years.

TIDES IN THE ATMOSPHERE.

As the atmosphere is as truly a *material* substance as the waters of the ocean, it is necessarily attracted by the Moon. It is therefore highly probable that there are much higher *tides in our atmosphere* than in the ocean, and that these air tides may yet be found to explain many terrestrial phenomena now involved in mystery.

THE HARVEST MOON.

The Moon, ordinarily, rises about 150 minutes later each day as already stated and explained. But there

are some days in the autumn when its time of rising varies, so that it appears above the horizon only from 17 to 25 minutes later each day, and thus gives us about 30 minutes more of moonlight. As this occurs about harvest time in England, it has been called the Harvest Moon.

The cause of this is owing to the fact, that the Moon's path around the earth is not always *equally inclined* to the *horizon*.

To illustrate: take two rings of such size that one will just fit within the other, and then incline them so that they will cross each other at a small angle. Now let the *outside* ring represent our horizon, and the *inner* ring the Moon's path around the Earth.

The Earth is supposed to be in the *centre* of the rings. Now it will be readily seen, that when the Moon is near the points of intersection of the rings, it moves more in a *horizontal* direction than when farthest from these points of intersection; hence, though the Moon is daily advancing in her orbit as usual, she will not sink so far below the horizon each day, because of this motion being more *horizontal* than in other parts of her path. As she has not sunk so far as usual below the horizon, she will of course rise sooner the next night, and will so continue for about a week.

This also explains what is called the Hunter's Moon, which occurs the month following the Harvest Moon.

This seems to be a special arrangements of a kind Providence to give the husbandmen additional time to gather the fruits of his toil, as the Harvest Moon rises about the time of sunset.

THE END.