HALF-HOURS IN AIR AND SKY

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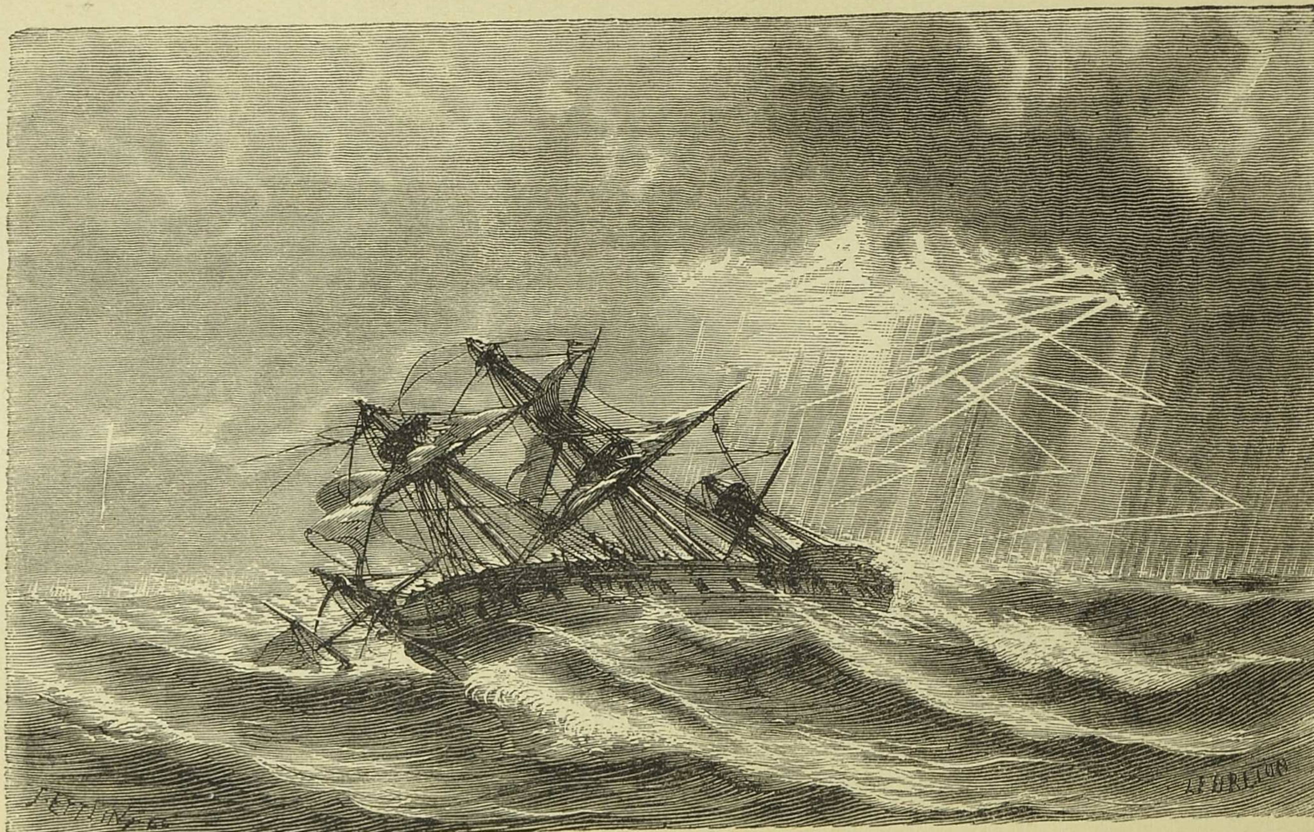

ELECTRICAL STORMS. (See Page 125.

THE HALF HOUR LIBRARY

OF TRAVEL, NATURE AND SCIENCE

FOR YOUNG READERS

HALF HOURS IN AIR AND SKY

Marvels of the Universe

WITH NUMEROUS ILLUSTRATIONS

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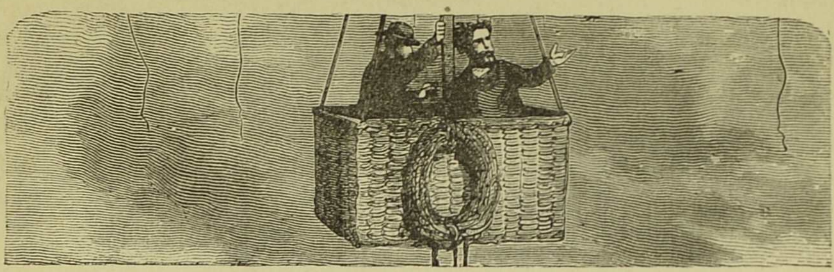

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WIND AND STORMS.

WIND AND STORMS.

CHAPTER I.

THEIR CAUSE.

NOTHING hardly is so common as the wind. But have you ever thought what wind is?

It is air blowing, air moving. Yes. But what makes the air move? How is it that there is ever any wind? How is it that it is not always calm and still?

That is one question to be answered. And here is another—

How does the wind in Great Britain here blow mostly from one of two quarters—from south-west or from north-east?

And here, again, is another question—

How is the south-west wind warm and the north-east cold?

And here, again, is another—

How is the south-west usually wet, and the north-east dry?

And here is another question, and the most interesting of all,—for it is a question not of How, but of Why; not of means, but of ends,—Why do the winds blow at all? What reason, and good reason, is there for their blowing? What good do the winds do to the earth, to the plants, to the animals, to men?

When we get that answered, even in part, we shall see how beautifully and wisely made the earth is, and the air round the earth. We shall see that the winds are indeed, as the Bible says, the winds of God; and that He makes the winds His angels; not angels in human form, such as you read of in the Bible, but angels still, fulfilling God's ends, going on God's errands, bearing life, and breath, and health, and food to man and beast, to the tallest tree in the forest, and the tiniest herb in the field.

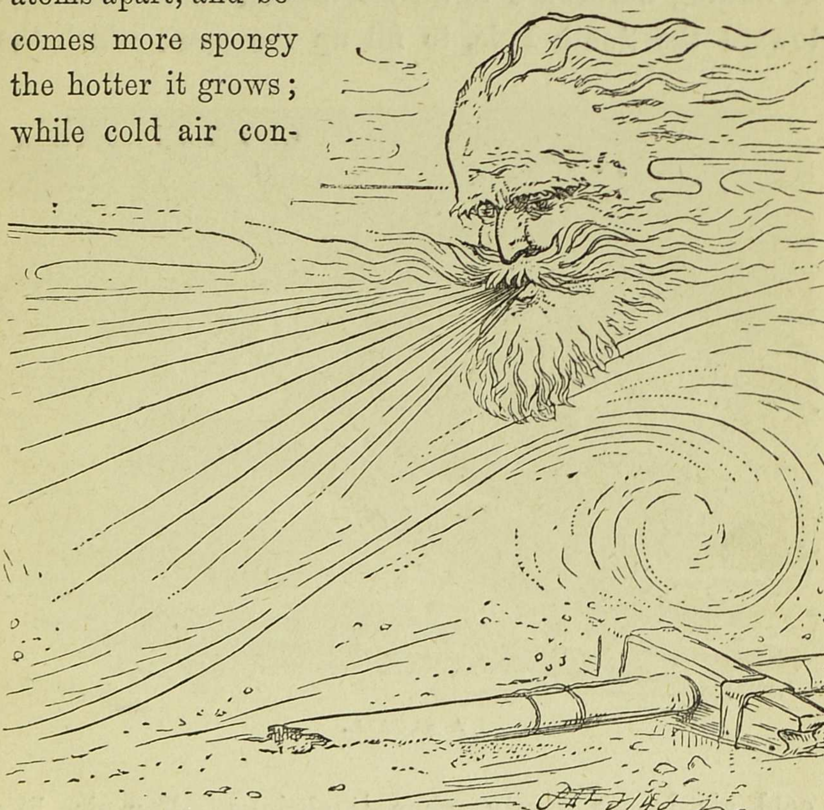
Now let us begin to answer one question.

How is it that the wind blows? What makes the air ever move?

You know the globe, the model of our earth. I dare say there is one in the schoolroom. You know the two Poles, the North Pole and the South Pole, where it is always cold winter. You know the Equator, between the two Tropics, where it is always hot summer. Near that Equator are the West Indies, where I was last year. Remember them, for there our south-west winds are made, and from thence they come. When I was there

I could see the south-west wind being made, day after day, and sent off to England.

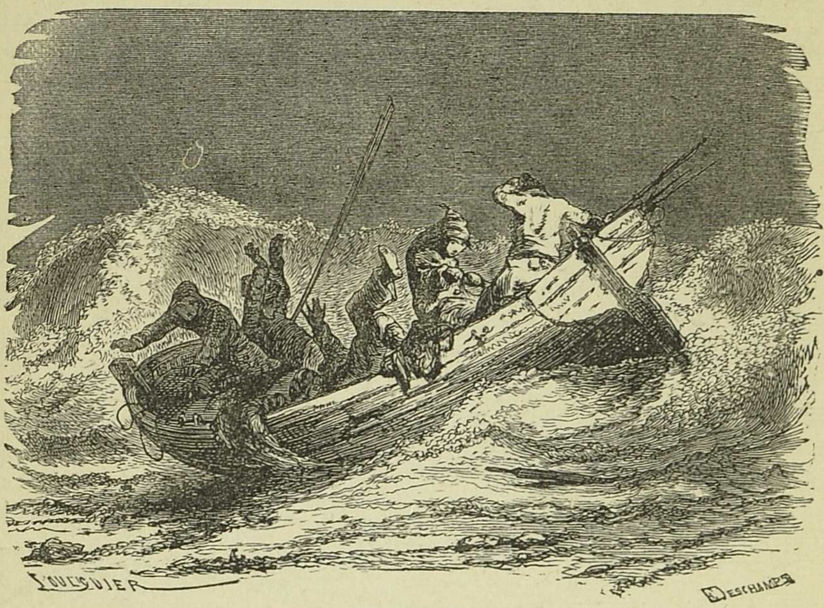
Now remember always that hot air is lighter than cold air; for hot air expands, that is, swells, and spreads its atoms apart, and becomes more spongy the hotter it grows; while cold air contracts, that is, shrinks, and closes its atoms together, and becomes more solid the colder it grows.



THE WIND.

But if hot air is lighter than cold, then the hotter it is, the more it must rise into the sky if it can; and the colder it is, the more it must sink toward the earth.

Therefore in the hot Tropics the air must be always swelling and rising, while at the cold Poles it must be always shrinking and falling. And what must happen then? That the hot air from the Tropics must always be flowing northward to the North Pole and southward toward the South Pole, to fill up the space which the



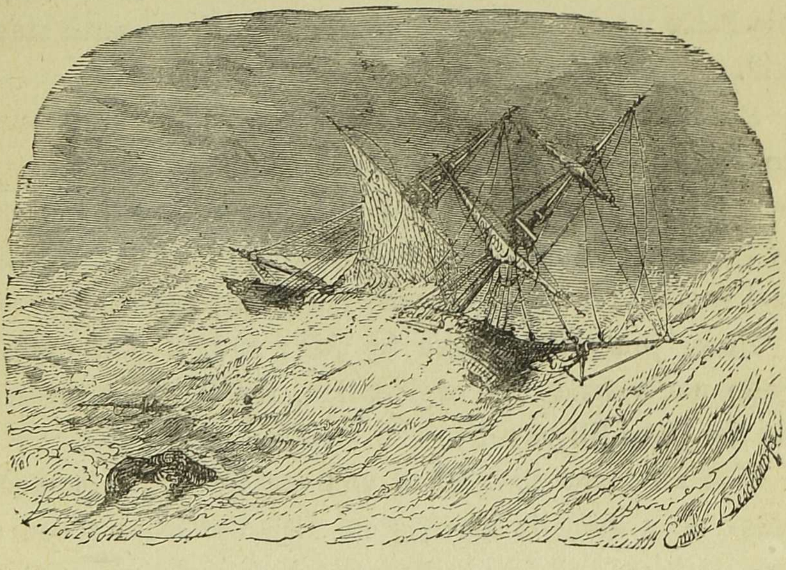
A SQUALL.

cold air leaves empty when it shrinks. For air, like water, is ready continually to flow in wherever it finds an empty space.

And so, if the earth stood still, there would be a wind always rushing towards the North Pole, and another wind always making towards the South Pole.

But there must be more than that. If only that went on, all the air would soon get to the Poles, and be packed up there ; and there would be too much air at the Poles, and too little at the Tropics.

Therefore the air from the Poles rushes back to the Tropics, to fill up the space left empty there ; and therefore there must be, if the earth stood still, a wind blowing down to the Tropics from each Pole, as well as



A TEMPEST.

a wind blowing up to each Pole from the Tropics ; that each may take each other's place, and keep up the balance.

Do you not quite understand? Why, you have seen the same thing happen in little a thousand times; and perhaps caught cold by it too. For how does the cold air, if there be a fire in the room, stream in through an open window or through a crack, and so make a draught? Because the fire heats the air in the room, and it becomes light, and flies away up the chimney, as the light hot air does towards the Poles. But that leaves too little air in the room; and therefore the cold air rushes in through the key-hole, and under the doors, and everywhere it can, just as the cold air rushes from the Poles to the Tropics.

So the mere difference of heat between the Tropics and the Poles would make two winds, even if the earth stood still.

But the earth does not stand still. It turns round on its axis, that is, on the Poles, once every twenty-four hours, to make day and night; and thus the course of the winds is altered, and, instead of blowing due north and south, they blow generally north-east and south-west.

Now, you must attend to this; and, if you do not quite understand our explanation, try it for yourselves on the globe till you do.

You all know that when you are travelling in a carriage your body is moving on with the same speed as the carriage, and keeps that speed if you jump out, till you touch the ground, and are stopped suddenly by it; so that if you jump out forward, the speed which your body has caught from the carriage will throw you on your face, if you do not take care; while, if you jump out backward—which I advise you never to do—the same speed will throw you on your back; and has stunned many a foolish person ere now by a tremendous blow on the back of his head.

Another example of this law, or rule, you may see when a man gallops a horse up to a fence, and the horse stops short. Where does the man go, if he is sitting loosely? Over the horse's head, and into the next field. He is moving with the speed of the horse, and when the horse stops he goes on.

Just so, anything heavy thrown out of a railway-train moves on for a while with the speed of the train, and if the train is going forty miles an hour, it will strike any one with a force of forty miles an hour. Therefore it is very dangerous—and, now you are warned, very wrong—to throw anything out of a railway-carriage while you are passing people or houses.

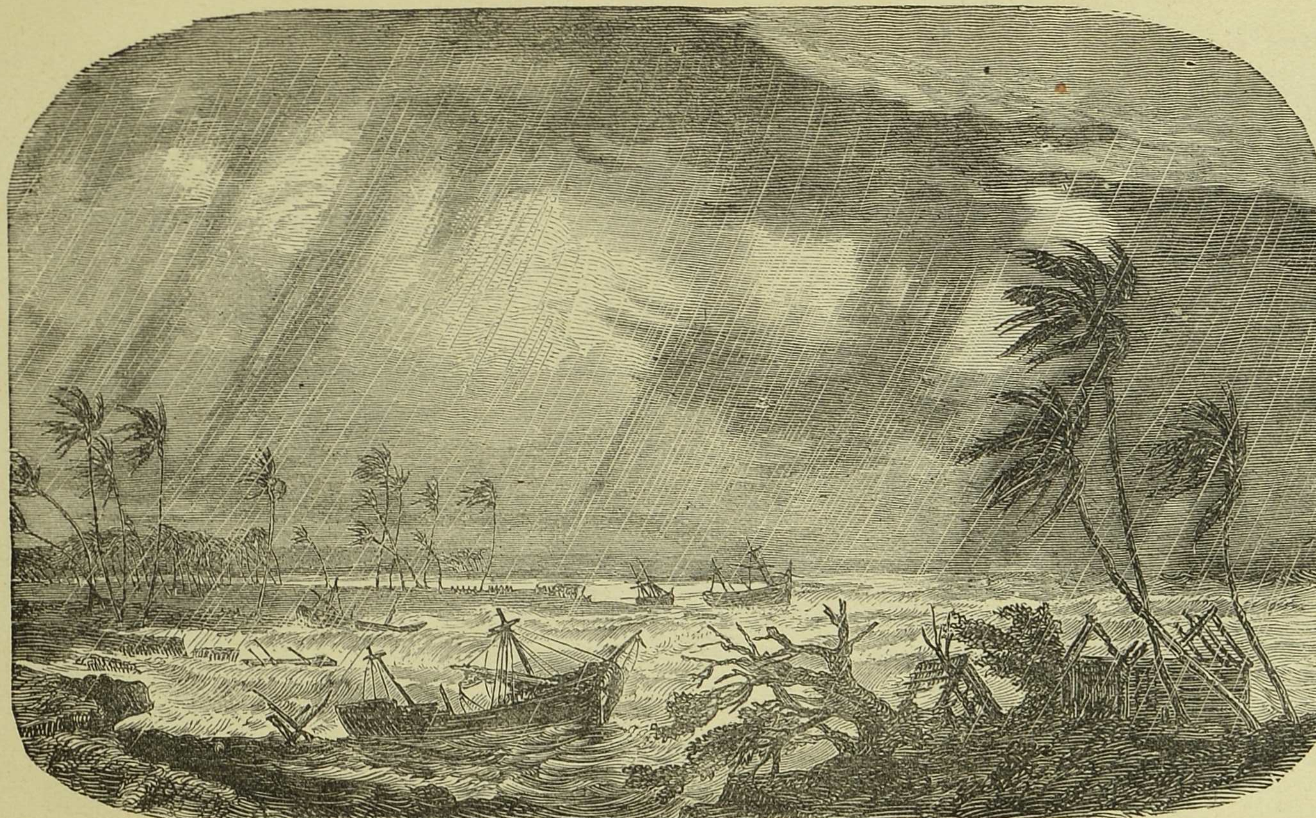
Now let us apply that same law, or rule, to the air in the West Indies, at the Tropics.

The earth there is 24,900 miles round—that is called the circumference of the earth; and it turns round once every twenty-four hours, from west to east. Now divide 24,900 by 24. What have you? 1,037½ miles. Therefore every little atom of air at the Tropics is going eastward with the earth at the rate of more than a thousand miles an hour. But as the air travels north the earth's circumference grows smaller the further north it gets. That you may prove for yourselves by measuring on the globe. But it all turns round in the same time—twenty-four hours. And therefore each spot on the globe is turning more slowly the further north it is.

Look, for instance, at St. Petersburg, in Russia, in latitude 60°. There the earth is only about half as much round as it is in the Tropics; therefore St. Petersburg is moving eastward only half as fast as the West Indies. For it has only 12,450 miles to go in twenty-four hours, while the West Indies have 24,900 to go in the same time.

But the hot air from the West Indies keeps up to something of that tremendous pace of a thousand miles an hour eastward with which it started; and, therefore, when it comes up to us here, it is going eastward much faster than we are, and when it gets as far north as St. Petersburg, much faster still—continually, as it were, catching us up, and passing us, in wind rushing from the west toward the east. So it is travelling east as well as north; therefore it is travelling, on the whole, north-east. But we name the winds not by the quarter which they are going to, but by the quarter which they are coming from. And as the wind comes to us from south and from west, we call it a south-west wind.

Do you understand that? If you do, you will be ready to ask another question. Why does not the south-west wind strike us here at the pace of hundreds of miles an hour? It blows usually some ten to twenty miles an hour only; and if it blows as hard as sixty miles an hour, we call it a terrible storm. Yet by my account it ought to be blowing over the north of Europe at five hundred miles an hour; and not much less here in England. How is it that it does not? How



STORM IN THE TROPICS.

is there not a perpetual hurricane here such as comes —but, thank God, rarely—in the West Indies, such as no man nor house could stand upright in, making England an empty desert?

That is prevented by one of those "compensating laws" by which the earth is rendered a fit dwelling-place for man.

The air is stopped continually by friction—that is, by rubbing against other air, and against the earth. The south-west wind comes up to us here—even the very fiercest gale—like a spent bullet bearing with its course through the air. It has to fight its way up against the earth, with its hills, and trees, and houses, all trying to stop it, and against the north-east winds too, which are rushing in exactly the opposite direction; and it is continually checked and baffled by them; and the fiercest gale which we ever felt is but a little strip or flake of it, which has, as it were, escaped, and run away for a few hundred miles. But it will be soon tamed down and brought to reason, by thrusting and grinding against the north-east wind coming down from the icy regions of the Pole.

And now let us talk a little of that north-east wind, and why it does not come straight from north all the year round.

Because, as with the south-west wind, the earth moves eastward on its axis.

Now the North Pole simply stands still, and turns round on itself, like the axle of a wheel, in the midst of snow and ice. At least, so wise men tell us. For I never was there, nor any one else, and I shall take good care that I do not go there, at least till I am turned into a whale or a white bear. But see now—Because the Pole is not moving eastward, the air round it is not moving eastward either; and therefore the cold air which starts from the Pole to go south, starts without any inclination to go east. But as it comes down, it finds the earth under it flying round eastward faster and faster, as it goes south. The earth is meeting it—I am sure you will understand—continually from the westward, and therefore we feel the north wind usually as a north-east wind, because we are rushing against it as we go east.

So we have a north-east wind going from the North Pole to the West Indies, and a south-west wind going from the West Indies to the Pole. This happens in our northern hemisphere—that is, the northern half of the world. But in the southern hemisphere, as you would find if you went to Australia, you have a south-east wind to answer our north-east, and a north-east wind to answer our south-east. And how that comes about, I leave clever children to find out for themselves—only telling them to remember what I have taught them already; for the very same rules that hold good here hold good there.

There is something grand to me in this perpetual struggle of the north-east and south-west winds, which is going on for ever a few miles over our heads, especially over these little islands of Great Britain and

Ireland, which are the very battle-fields of the two great winds, "the Tropic and the Arctic currents," as learned men call them. And therefore it is that the weather in these islands is so changeable, that, as really wise men say, you never can tell what it will be for three days together.

Therefore, I advise all sensible children, and grown people too, never to put faith in prophecies about the weather. He must be a very wise man who can tell you if it will be fine the day after to-morrow, and still more a week hence; and he can only do that in a part of the country which he knows well from long experience. For the two great winds are always wrestling and jostling over our heads, each determined to have its own way, and to get to its own home; and which of the two will conquer for the week is more than man can know.

WIND AND STORMS.

CHAPTER II.

CYCLONES AND TRADE-WINDS.

CYCLONES and Tornadoes, what are they? They are one and the same thing.

They are wind-storms which revolve round a centre just like a turning-wheel round its axis. The name by which this kind of storm is known is Cyclone in the East, and Hurricane or Tornado in the West.

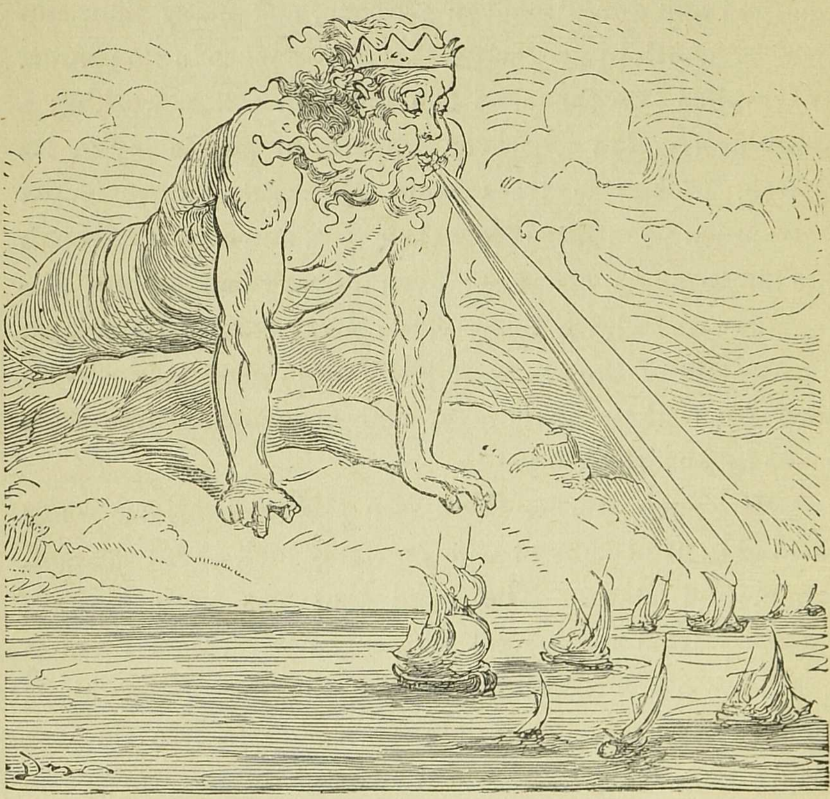
A revolving storm increases its velocity as it continues to roll; in severe hurricanes it rotates at the rate of a hundred miles an hour. These storms not only move round, but they also move along a direct line—just as a spinning-top which, whilst it is spinning, is moved by the string from one part of the table to another. The top has two motions, the one around its point, the other along the table; so has the cyclone, revolving as it goes, being carried in whatever direction that outside wind may be blowing.

Most terrible and desolating storms these are. One which visited the West Indies in 1831 destroyed, in the space of seven hours, no less than one thousand four hundred and seventy-seven persons, and many thousand pounds' worth of property; this at one place in its course. It travelled two thousand five hundred miles, working a great destruction wherever property or people lay in its course. Gigantic trees were uprooted, houses blown down, men were lifted from their feet, and carried through the air to some distance; even a heavy cannon was dismounted and blown many yards away from its carriage. The waters of the sea were piled up in heaps, ships were torn from their anchorage, and cocoanut groves were made into mere chip yards.

Before such storms there is a stifling heat, a strange lurid sky, fitful puffs of wind, a sickly look about the sun, moon, and stars. The wind that has been blowing furiously from south-west suddenly ceases, then there is a lull for a few minutes, and then the tremendous blast. At sea it is scarcely possible for a ship to live through them; and, indeed, once in the trough of the waves she must inevitably go down.

Lady Barker has given a graphic description of such a storm:—

"Never have I seen such a wonderful sunset as made all the western heavens glorious that evening. No picture that ever was painted, no words which exist, can show it to you. It was impossible to look at it without a feeling of awe as well as of admiration. Great banks of cloud lay piled in crimson and purple masses along the horizon, every here and there was a wide rift in their glowing



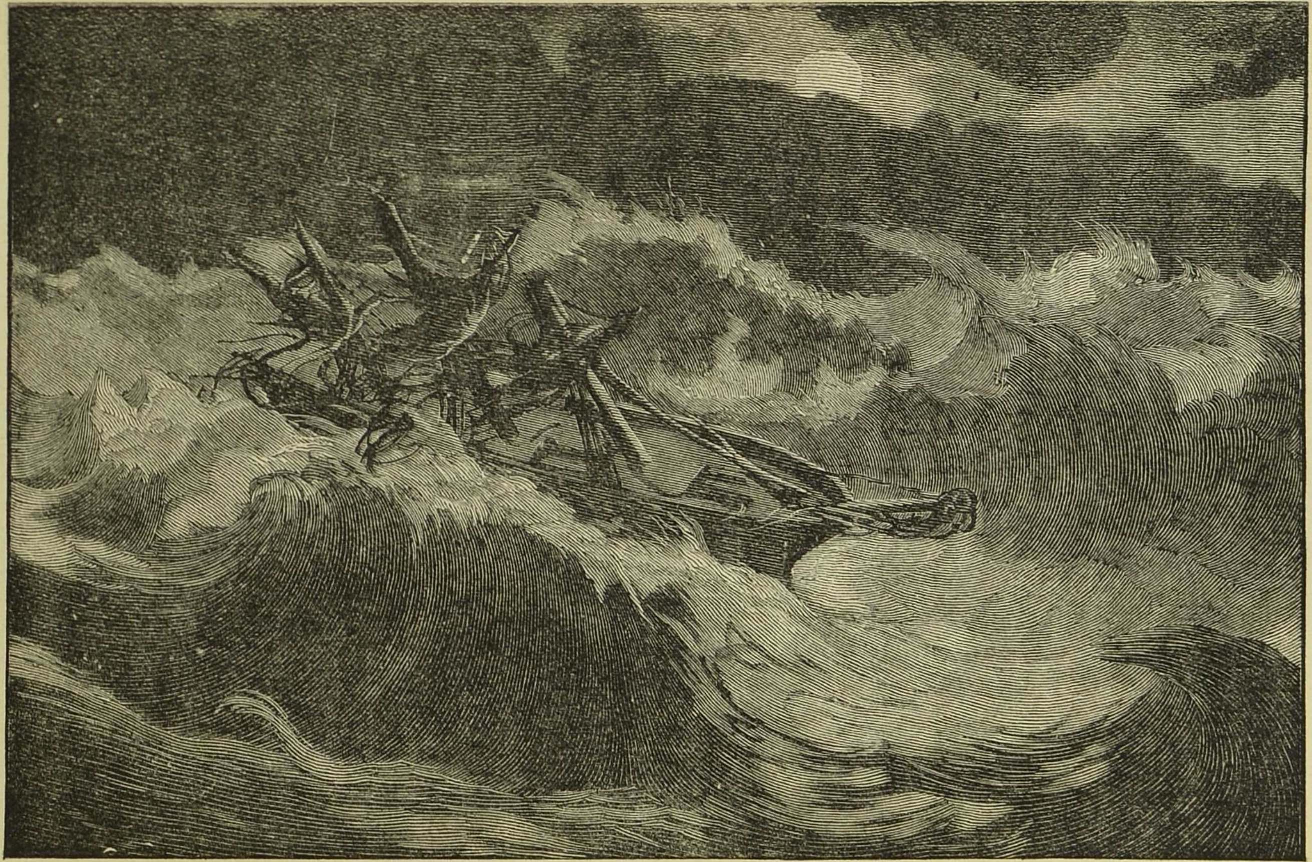
THE KING OF THE WIND.

depths, beyond which lay a calm, lovely glimpse of what one felt *must* be heaven, with its floor of a clear dazzling blue, melting away into a wonderful pale green tint impossible to describe. The shape of these cloud-Alps changed, as we gazed, from a lofty mountain range into a battlemented city, with spires and minarets and domes rising behind the aërial walls. Then spectre forms of knights and men-at-arms loomed like phantom giants out of the lurid, fleecy mass, and we held our breath at what looked like the reflection of a fierce battle in the sky, changing in its turn into strange shapes of monsters, compared with which the gigantic animals which inhabited the world before the Flood must have been harmless pets.

"I remember feeling half provoked with the captain, and, indeed, with all the officers of the ship, for not sharing in my enthusiasm; they looked, it is true, at the splendid changing tints which were reflected over half the sky, but their glances showed no admiration, nothing but anxiety, and I heard one sailor say, 'It's the *illest* sight that ever I did see; there's a blow brewing there, or I'm a lubber.' But it seemed as if they were wrong in their foreboding, for we had a dull cloudy day on the morrow. Yet there was a heavy, oppressive feeling in the atmosphere, and the waves heaved restlessly; the barometer fell lower and lower, and more anxious grew the looks which were cast up aloft, and all round the wide horizon. Sunset brought yet more glowing orange and scarlet to mingle with the purple and crimson tints repeated over the steadily increasing bank of clouds to the north-west. Our eyes were so dazzled by the colouring, that we could hardly look at it for more than a moment at a time. I heard the grim old quartermaster mutter, 'Oh yes, it's all very well to say, "How pratty it is!" ye mayn't ever see another, pratty *or* ugly, I'm thinking.'

"This was in answer to the openly expressed admiration of one of the passengers. About midnight both the wind and the sea rose, but when I came on deck after breakfast I was quite surprised to see the preparations for bad weather which were going on in every direction. To use a nautical expression, things were being 'made snug,' and the carpenter was busy fastening down hatchways by nailing sails and tarpaulins securely over them. Up aloft every sail was furled, and the upper yards were lowered; the ship was scudding along under steam, and there was an indescribably angry look in both sea and sky. As for the waves, they looked as if they were made of mud instead of water, and the sky matched them exactly. Another thing which struck me unpleasantly was that, instead of the beautiful boundless vault of blue heavens, with a light cloud flecking it here and there, to which we had so long been accustomed, there weighed down and enfolded us a dense thick mist, which was neither rain nor cloud: it seemed as if the sky was sinking down and crushing us. Through this vapour we could discern nothing.

"As the day wore on, we heard minute-guns firing on our starboard quarter, telling of some ship in dire distress; but we had enough to do to take care of ourselves, for although we seemed to have been working hard at our preparations for many hours, the storm was upon us, or rather we had steamed into it, before we were half ready.



IN A CYCLONE.

The waves hit the ship hard, vicious thumps, as if they hated her and longed to crush her to pieces; she, poor thing, groaned and laboured heavily, going down, down into a gloomy, dun-coloured abyss of water, where she shivered and shuddered, straining every timber, and creaking at every plank, as if she really could not manage to get up again, and intended to give in and settle quietly at the bottom of the sea; then, when she had wearily dragged herself up to the top of a huge wave, it was only to plunge into another water-valley, and so on.

"Every now and then a great body of water would fall heavily on the deck, but so thick and murky was the atmosphere that we could not see it coming. A wall of some dun-coloured vapoury substance loomed over us, but whether it was air or water no one could tell until it flooded us. Up to this point, however, I don't believe there was any reason for thinking hopelessly of our condition; but by the third day things began to look very bad, and the captain and sailors wore gloomy and anxious faces.

"I can assure you the time passed very heavily down below. All the skylights were fastened securely up, so were the strong shutters (or 'dead lights,' as they are called) to the cabin port-holes, and we were in utter darkness, except for the glimmer of an oil-lamp in the passage. Most of the passengers left their cabins, and preferred to lie on mattresses in this sort of long corridor, I suppose for the sake of company, but they looked very wretched; some were groaning, some were crying, some were praying, all were frightened, as well they might be!

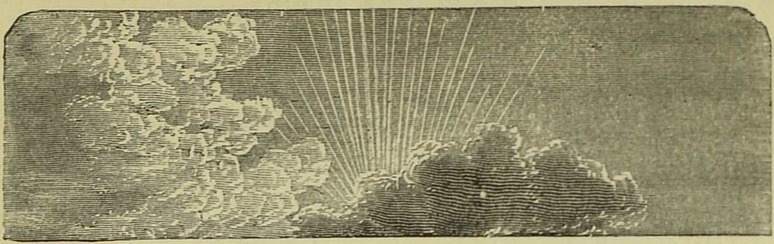
"In a water-logged vessel, without masts, without a rudder, steering by some sort of rude contrivance, with broken engines, and with the pumps going day and night to keep us afloat, we reached our third day. During all this weary time the sky had not cleared for one brief instant to allow us to take an observation and find out where we were, and we could not see a yard before us. The gale showed signs of abating, or we were blundering out of its circle; but the sea was running mountains high.

"All through the day and night we could hear the hoarse cry of 'Breakers ahead!' or else 'Breakers on the port bow!' or 'Breakers on the starboard bow!'" according to the way we helplessly turned, hoping to find a way out of our difficulties. Ever since the beginning of the storm no one had been able to sleep on account of the incessant uproar of the winds and waves, to which was added an equally terrible creaking and straining of the vessel's timbers. Mingled with these sounds were shouts, screams, and at first constant crashing of glass and china; but very soon *that* came to an end, for the last of our plates and dishes were reduced to fragments, only fit to be thrown overboard. We now were in hourly expectation of the ship either foundering or going to pieces on a rock; and yet many of us were dozing, quite worn out with nearly a fortnight of sleeplessness, excitement, hunger, and misery.

"The next evening, just as we were making up our minds for another night of darkness and discomfort, we heard above the roar of the sea the report of a gun close by. We answered it by sending up a blue light to show where we were, and in a few moments the stately hull of a splendid large ship loomed out of the fog close to us. All night she kept near us, blowing her steam whistle and letting off blue lights. We burned one regularly every hour, and as soon as the day dawned she fired rockets with a rope attached to the stick, until we managed to get hold of one, when she took us in tow, and on the fourth day after Christmas we entered the Hooghly in the wake of our big friend. We had no masts, and looked the water-logged wreck we were."

There is another wind, a wind most beneficent, known, because of its great service to trade, as the trade-wind. It is always blowing from the same quarter of the globe. It was Columbus who, on his first American voyage, ascertained the extent over which these winds blow. They come from the north-east, and of course blew dead against his ship's return to Spain. For this reason his ignorant crew grumbled their fears about getting back to their native land again, declared that God was angry with them for presuming to pry into His secrets in the West, and had given them over to the power of the devil, who had caused this wind to blow to prevent them ever returning to their homes. Poor fellows! The power of the devil, indeed! It is that wind which carries food and clothing and tools for a whole world. The name trade-wind was doubtless given because it is a fixed wind, and anything that is certain, from the punctuality or the honesty of a clerk up to a sea breeze, is always sure to have the good-will of merchants. This wind is one thing on which voyagers can rely. The force of this wind is sufficient to propel a ship regularly at the rate of sixty miles a day.

AMONG THE CLOUDS.



AMONG THE CLOUDS.

CHAPTER I.

SUBSTANCE AND VARIETY.

THE air is a blending of subtle gases, of which more than ninety-nine per cent. consists of oxygen and hydrogen, a great part of the remainder of aqueous vapour and carbonic acid, with other gases in very small proportions.

These quantities prevail at all elevations, whether among mountains or vertically in space, up to the greatest height which has yet been attained.

For miles above the earth a variable quantity of water is mixed with the air. It is this union of two dissimilar fluids which produces the whole visible phenomena of cloud, haze, fog, &c. Whenever the temperature of the air declines from any cause, the moisture which at the higher temperature was in the invisible form of vapour, is condensed, and assumes the visible shape of clouds.

The clouds are specifically lighter than the atmosphere they float in, but the mode of their suspension has not yet been well determined. Gay-Lussac attributes it to upward and horizontal currents, and Howard to electrical agency.

Be this as it may, different modifications or varieties of cloud exist at various elevations, and prevail according to the season of the year, the time of day, and the amount of water absorbed into the atmosphere.

Early in the present century, Howard published his celebrated treatise upon clouds, and devised the nomenclature ever since in use.

The primary modifications, he remarks, are as distinguishable from each other as a tree from a hill, or a hill from a lake; although clouds in the same modification, considered with respect to each other, have often only the common resemblance which exists among trees, hills, or lakes, taken generally.

The three principal modifications he names, and thus defines:—

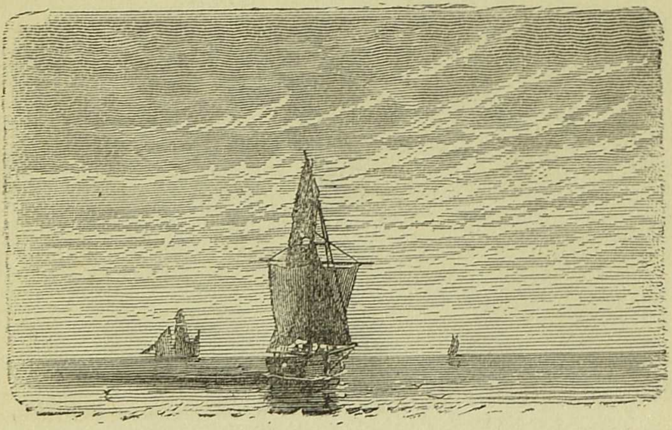
1. Cirrus.—Parallel curl-like fibres.

2. Cumulus.—Convex or conical heaps, increasing upward from a horizontal base, mountain-like.

3. Stratus.—A widely extended, continuous, horizontal sheet, increasing from below upward, plain-like.

He assumes that vapour thrown into the atmosphere by the process of evaporation, is diffusible by its own elasticity, which suffices for its ascent to any height in a perfect calm; and that clouds are the aggregation of minute drops, influenced in their method of grouping by electrical agency, the exact nature of which remains unexplained.

Vapour generated from any moist body by evaporation, ascends by its less specific gravity, losing heat, both by its own expansion and by its ascending to the colder air of the upper regions and mixing with it. When in the balloon, I have seen mist or vapour, rising from marshy ground and water, dissipate in a region relatively dry; at other times vapour has risen, invisible at first, but, pass-



CIRRUS—CURL-LIKE CLOUD.

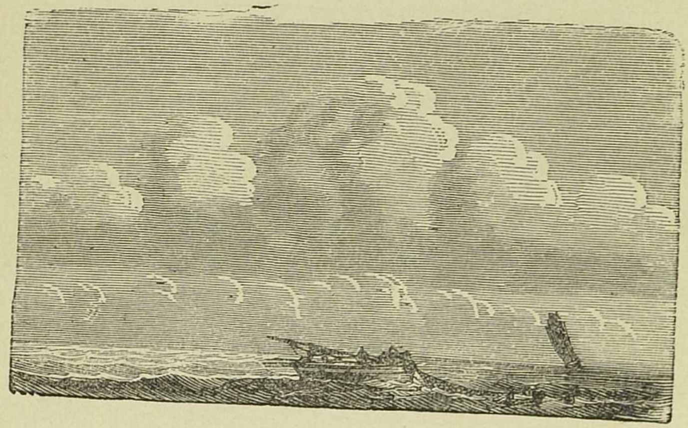
ing through higher regions where the relative degree of moisture has been great, indeed nearly approaching to saturation, it has assumed visible substance as cloud.

Fog, mist, and haze may be assumed to illustrate the most elementary forms of condensed vapour, and to contain the simple elements of more perfect cloud formations. Of visible vapour, they are modifications of different degrees of density.

Haze is the least opaque: rising from the surface of the ground, it fades by imperceptible degrees into the ordinary transparent atmosphere.

Mist is a local phenomenon, appearing chiefly in early morning or towards nightfall, and hovers like an embryo cloud for a few feet over meadows or moist surfaces, sometimes rising from the ground or creeping along the soil.

Fog is the most important modification of the group:

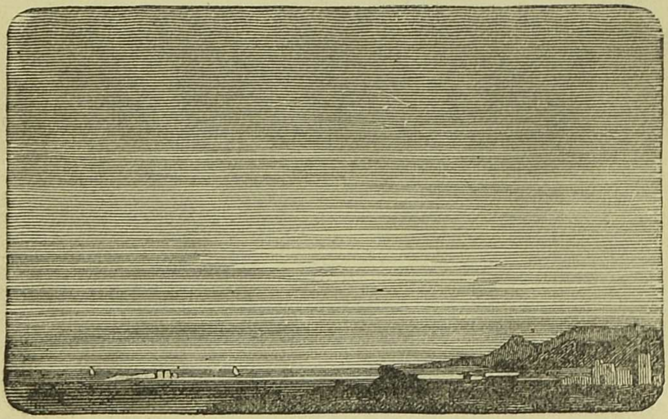


CUMULUS—MOUNTAIN-LIKE CLOUD.

it exists at the highest elevations, is the most general, and, without question, is the most dense. It is dry or wet, and may exist in either state, in successive alternate layers, to a considerable height above the ordinary level of the clouds.

The condensation of an aqueous mist consists probably in the formation of a multitude of thin vesicles of lighter specific gravity than the surrounding air.

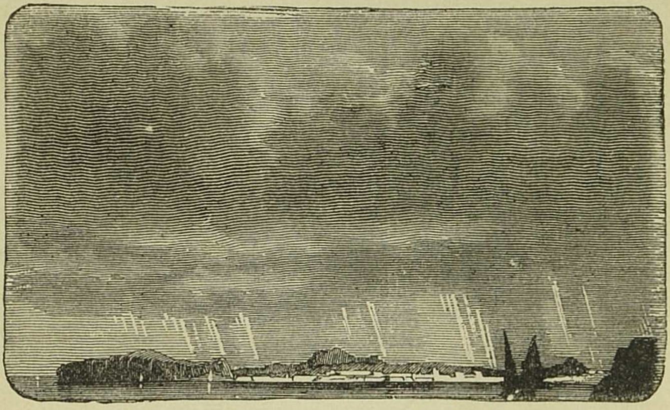
So far as I have seen, a cloud does not consist of solid drops, but of vesicles, bladder-like, after the manner of a soap-bubble, although I have never seen anything like a bladder in any cloud I have been in. That the atoms are vesicular, I rather infer from their floating, and from the optical phenomena of clouds and mists, the rainbow, halo, and corona; and from being enveloped in fog when the known amount of water present has been exceedingly small.



STRATUS—PLAIN-LIKE CLOUD.

For instance, it is generally understood that a cubic inch of water produces a cubic foot of steam. When at heights exceeding four miles, and when there was less than one 2000th part of a cubic inch of water in a cubic foot of air, a bulk of vapour or cloud has been produced sufficient to envelope us in fog. Not only did this drop of water, one 100th of an inch in diameter, in a cubic foot, make itself visible, but everything else was hidden from view. So small a solid I think must have been dispersed in a vesicular form to fill so large a space.

I have, however, as I have said, never seen any bladder-like bodies in clouds. This vesicular formation, by the lighter specific gravity of its particles, would account for the suspension of clouds. But whether vesicular or minute solid drops, the measure and degree of electrical agency upon their ultimate form and structure is little else than conjecture.



NIMBUS—RAIN CLOUD.

The three divisions I have named occupy respectively a distinct region of the atmosphere.

To the Stratus is assigned the lowest elevation, and the least development of form and structure. Its spreading vapours mix at nightfall with the creeping mists of evening, and afterwards descend in one unbroken sheet towards the surface of the earth. Its broad level plains float nearer to the ground than other modifications.

ABOVE THE CLOUDS, NIGHT.

To the Cumulus is given a higher elevation and more perfect development. Whether viewed from a balloon above, or from the earth beneath, it bears an important part in the scenery of the clouds. Of the densest structure it is formed in the lower regions of the atmosphere, and travels with the current nearest to the earth.

Ascending from an irregular base, clouds of this modification rise into conical rounded heaps. They belong to the morning hours, and begin to form shortly after sunrise, attain their maximum in the hottest part of the day, diminish by degrees, and perfectly disperse about sunset. The Cumulus of fine weather floats at a moderate elevation, and belongs to a region above the Stratus.

Clouds of this division form a natural screen to protect the earth from the direct rays of the sun in the hottest weather; and by reflexion diffuse heat throughout the atmosphere.

Before rain they are more fleecy and of looser texture than in settled weather.

When, towards sunset, instead of dispersing, they continue to rise, they betoken the approach of thunder.

At the highest elevation float the fibres of the Cirrus, parallel, or grouped into feathery tufts, which resemble a lock or curl of hair. Their duration is uncertain; but in fine weather, with light variable breezes, the sky is seldom clear of small oblique groups of Cirrus.

From the car of the balloon, at a height of several miles, I have seen this cloud still many miles higher.

It is the least dense of clouds. In periods of wet weather it is attracted into thin horizontal sheets, and forms at a lower elevation, subsiding into Stratus. Its fibres, miles in length when parallel, converge to a point in the horizon, in obedience to the laws of perspective. In feathery whisks, curled or diverging, it is popularly known as the mares' tails.

It travels with the higher currents of the atmosphere, but is more often motionless. Its long extensible fibres frequently extend in parallel bars from horizon to horizon. Howard has estimated them to be at least sixty miles in length; but at times they must be of far greater extent. In its purest form its delicately white-pencilled threads are collected into groups of oblique Cirrus, or extend digressing across the sky. Floating at an elevation where the temperature is much below the freezing-point, they are believed to be formed of frozen particles, beyond the milder influences of the earth.

From the great elevation of the Cirrus, we may fairly assume it to be crystalline, an opinion strengthened by the fact, that it reflects, together with its derivative forms of cirro-cumulus and cirro-stratus, halos, coronæ, and other optical appearances referable to the refraction and reflection of ice-crystals, which almost invariably appear in the Cirrus and its modifications.

AMONG THE CLOUDS.

CHAPTER II.

LUNARDI'S BALLOON ASCENT.

IN the year 1784, on September 15th, a young Italian, Vicenzo Lunardi, secretary to the Neapolitan ambassador, distinguished himself as the first aërial traveller in the English atmosphere.

He first conceives the design of interesting generosity and humanity in the patronage of an experiment of some hazard, and determines to ascend from Chelsea Hospital, "as from the altar of humanity, to ascend the skies." He writes, therefore, to George Howard, governor of the Hospital, and wishes to be assured of a place for launching his balloon, to which none but subscribers shall be admitted. The gain over and above the expenses of the undertaking, he proposes shall be divided among the invalids of the Hospital; and the governor, with the approbation of his Majesty King George III., accedes to his request.

The advertisement appears, and announces the construction of a globe thirty-two feet in diameter.

Its purpose is to ascend into the higher regions of the atmosphere, subject to various interesting experiments.

It is to drift for miles before the wind, and to range not higher than a gunshot above the earth.

His globe is made of the best oiled silk, and is filled with inflammable air (hydrogen gas); it is fitted with a gallery or car, oars, and wings.

To guinea subscribers, Signor Lunardi promises admission to Chelsea Hospital gardens on the day of ascending, a chair near the globe, and admission, four different times, to view the construction. The half-guinea subscribers will be admitted likewise to the gardens, and will have seats on benches next the chairs, and will be admitted twice to see the construction of the machine.

To his sanguine expectation the advertisement put forward appears certain to be realised. In the fulness of this expectation he writes: "England is open to all the world, either in war or peace; and a man of talent, whether liberal or mechanic, cannot fail of support and encouragement in proportion to his merit. Here the prodigious resort of strangers has nearly destroyed that indiscriminate species of hospitality which prevails on the Continent. But when once a circumstance in the situation or character of a stranger has attracted the notice of an Englishman, and he has declared himself his protector and friend, it is worth a thousand of the civilities of general hospitality; a reliance may be had on its sincerity, and the friendship is permanent in duration as it is slow in growth."

A little later all his anticipations are changed; and he writes in an embittered spirit: "The events of this extraordinary island are as variable as its climate. It was but lately, everything relating to my undertaking wore a favourable and pleasing appearance; but I am at this moment overwhelmed with anxiety, vexation, and despair." This trouble is caused by a ridiculous failure on the part of one Moret, a Frenchman, who had advertised an ascent in competition. To witness Moret's ascent a concourse of fifty or sixty thousand people assembled in the gardens, and waited from one to four o'clock with patience for the filling and ascension of the balloon. But when it failed, and in spite of every attempt sunk into the fire which expanded it, the people, imagining the whole affair an imposture, rushed in and "tore it to pieces!" and, adds our disconsolate informant, "spread desolation and terror through the whole district."

In consequence of this ridiculous catastrophe, and the riots which ensued, Sir George Howard forbids the ascent from the gardens of Chelsea Hospital; and it appears likely the undertaking must be relinquished. Popular ridicule and sarcasm, aimed at the sincerity of his attempt, stigmatize Signor Lunardi as an impostor and colleague of the unfortunate Moret.

By dint of exertion and private interest he at length gains permission to ascend from the ground of the Honourable Artillery Company, the Prince of Wales having promised to be present.

The morning of the ascent arrives.

The Artillery corps have promised to appear under arms for the purpose of preserving order and regularity, and Signor Lunardi is at the climax of excitement. He retires frequently from the ground to record the passing impressions of the moment, and writes to his friend, "The auspicious morning has arrived. I have no apprehension but of the populace, which is here, as it is everywhere, an impetuous, impatient, and cruel tyrant."

At twelve o'clock an immense concourse has assembled, collected into one compressed and impenetrable mass. Our enthusiast retires for a moment into an upper room of the Artillery House. "The view," he writes, "would suggest to a tyrant the idea of a pavement of human heads; but I conceive the risk of going up in my balloon trifling, compared with that of attempting to walk on the living surface I now contemplate. One hundred and fifty thousand countenances all turned in one direction!"

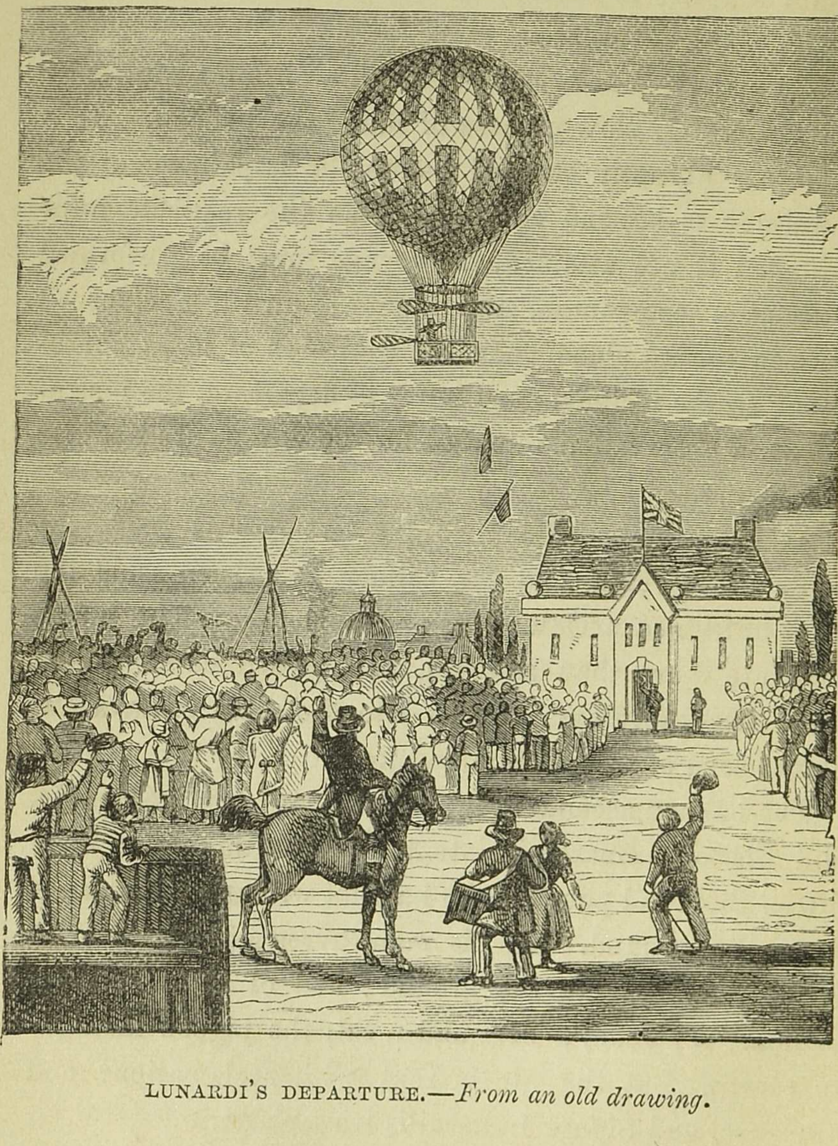
By half-past one o'clock the Prince of Wales has arrived, and the time fixed for the departure of the balloon has become exceeded. The Prince of Wales remains near the apparatus to see it filling, in preference to joining the company in the house. He directs his questions with an intelligent curiosity, and occasionally expresses a wish for the safety of the aëronauts, as if not destitute of doubt. Signor Lunardi is not to ascend alone, but has accepted the offer of a young gentleman of fortune and enterprise to share with him the danger, if not the glory, of the adventure.

The narrative re-commences with a dilemma caused by the elaborately slow process of filling the balloon. It is therefore abruptly stopped before the impatience of the multitude is beyond control, but as the requisite force intended is not attained, the voyage must be performed without a companion, and Signor Lunardi decides at once to ascend alone. In the confusion of ideas consequent on the incidents and hurry of departure, the instruments of observation intended for the voyage are likewise left behind.

At five minutes after two the last gun is fired, the cords are divided, and the balloon has risen, amid the most unfeigned acclamations and applause. The multitude are more than satisfied, and passed in a moment from incredulity and menace into the most extravagant expressions of approbation and joy.

The balloon ascends to the height of two hundred yards, and Signor Lunardi is intent on exhibiting himself to fifteen thousand people, who had not witnessed his ascent from the ground. In his manœuvres an oar becomes broken, and falls to the ground; and of his three companions, a pigeon, a dog, and a cat, the pigeon manages to escape. But the air is rent with acclamations and applause, and Signor Lunardi is triumphant.

The temperature falls from 68° to 61°, and the change is readily perceptible; the globe is rapidly advancing



LUNARDI'S DEPARTURE.—*From an old drawing.*

upwards, and the delighted aëronaut, released from apprehension, applies himself to his provision. He refreshes himself with a few glasses of wine and the leg of a chicken ; but the bread, and some other edibles, he writes with amusing precision to his friend, have become mixed with the sand, and spoiled.

With the thermometer at 50°, and no personal discomfort pressing upon his attention, he experiences a calm which he describes as inexpressible, and which no situation on earth could give. He writes :—

"The stillness, extent, and magnificence of the scene rendered it highly awful. My horizon seemed a perfect circle ; the terminating line several hundred miles in circumference ; this" (he continues) "I conjectured from the view of London, the extreme points of which formed an angle of only a few degrees. It was so reduced on the great scale before me that I can find no simile to convey an idea of it. I could distinguish St. Paul's and other churches from the houses ; I saw the streets as lines, all animated with beings whom I knew to be men and women, but which I should otherwise have had a difficulty in describing. It was an enormous beehive, but the industry of it was suspended. All the moving mass seemed to have no object but myself, and the transition from the suspicion, and perhaps contempt, of the preceding hour, to the affectionate transport, admiration, and glory of the present moment was not without its effect on my mind. It seemed as if I had left below all the cares and passions that molest mankind. I had not the slightest sense of motion in the machine. I knew not whether it went swiftly or slowly, whether it ascended or descended, whether it was agitated or tranquil, but by the appearance or disappearance of objects on the earth. The height had not the effect which a much less degree of it has near the earth, that of producing giddiness."

Passing from the history of his sensations, he next turns his attention to the view, which he admits he cannot accurately describe. "The gradual diminution of objects, and the masses of light and shade," he observes, "are intelligible in oblique and common prospects, but here everything wore a new appearance and had a new effect. The face of the country had a mild and permanent verdure to which Italy is a stranger. The variety of cultivation, and the accuracy with which property is divided, give the idea, ever present to the stranger in England, of good civil laws and an equitable administration. The rivulets meandering; the immense district beneath me, spotted with cities, towns, villages, and houses pouring out their inhabitants to hail my appearance! You will," he adds by way of apology, "allow me some merit in not having been exceedingly intoxicated with my situation."

To prolong his enjoyment of the scene beneath him, he tries the effect of his remaining oar, and thinks he succeeds in keeping the same parallel with the earth for nearly half an hour; but the exercise is fatiguing, and, satisfied with his experiment, he sits down calmly and resumes his pen.

During his excursion he writes three letters, besides making some desultory observations. The first are committed successively to the winds, on the chance of their falling into the hands of his friends, and relieving their anxiety on his account.

While he writes the balloon has been ascending rapidly. Of this he is warned by the decreasing temperature, which falls to 32°. The balloon, at first but partially inflated, acknowledges the difference of height, and assumes the form of an oblong spheroid, the shortest diameter of which is in a line with the aëronaut. On its first ascension it held the form of an inverted cone, wanting very nearly one-third of its full complement of gas. There is no valve, and he can only open the neck of the balloon, on the chance that the strong rarefaction might force out some of the inflammable air.

The vapour around its neck is frozen. Reminded by this test of temperature that he is at his highest elevation, he looks again at the earth, which appears like a boundless plain, whose surface has variegated shades, but on which no object can be accurately distinguished.

At half-past three o'clock he descends in a cornfield on the common of South Mimms, where he lands the cat, the poor animal having suffered greatly from cold.

His descent, he thinks, is effected by the action of his single oar working vertically. The people about come forward to assist at his disembarkation, but he wishes to obtain a second triumph; he throws out the remainder of his ballast and provisions, and bidding them stand clear, ascends again in their view.

A second time he sits down to write, but his ascension is so rapid, that before half a page is written, the thermometer has descended to 29°, and the balloon is fringed with icicles. This is the highest elevation he attains, and his letter finished, he fastens it with a cork-screw to his handkerchief and throws it down. He also (contrary to the modern usage of Mr. Coxwell, who is a strict disciplinarian), forgetful of the impetus they would attain in falling, throws down the plates, knives and forks, the little sand that remained, and an empty bottle, which takes some time in disappearing.

"The earth," he writes, "appears as before, like an extensive plain, with the same variegated surface; but the objects rather less distinguishable. The clouds to the eastward rolled beneath me in masses scarcely larger than the waves of the ocean. I therefore did not mistake them for the sea. Contrasted with the effects of the sun on the earth and water beneath, they gave a grandeur to the whole scene which fancy cannot describe."

At twenty minutes past four he descends in a capacious meadow, near Ware, in Hertfordshire. Some labourers are at work in the field, but they refuse to come forward to his assistance. At length a young girl advances to take the cords which he has thrown out, and Signor Lunardi records with indignation, that on calling

BALLOON IN TROUBLE.—*From an old drawing..*

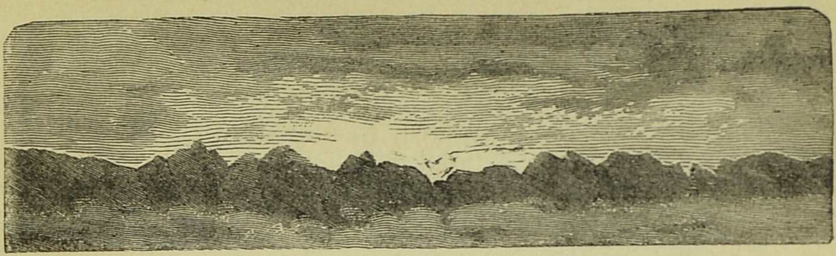
to the men, they even denied to her request what they had refused to his.

A crowd presently assembles, and he recognises General Smith, who has followed him from town on horseback, and who assists him in securing the balloon. It is made captive, and the inflammable air is let out by an incision, but it nearly poisons the neighbourhood by emitting a most offensive stench. The apparatus is then confided to the care of a Mr. Hollingsworth, and is some time after exhibited at the great room of the Pantheon, one of the largest rooms then in London, and now the Pantheon Bazaar. The party adjourned to the Bull Inn at Ware, and Signor Lunardi is introduced to William Baker, Esq., M.P. for Hertford. This gentleman conducts our hero to his seat at Bayford Bury, and wins his admiration for the frank and generous hospitality with which he receives him.

On his recovery from the illness which ensues from overwrought excitement, Signor Lunardi finds himself the lion of the season, and he records with naïve delight that his Majesty, in council with his ministers, broke up the conference to look at him in passing, and, attended by Mr. Pitt, viewed him through a telescope while he remained in sight. The eager populace is anxious to make him amends, and he is offered the houses and scaffolding near for his own use, if he chooses to exhibit again.

"My fame," he writes, "has not been sparingly diffused by the newspapers (which in England are the barometers of public opinion; often erroneous, as other instruments are, in their particular information, but yielding the best that can be obtained). You will imagine the importance of these vehicles of knowledge when you learn that in London alone there are printed no less than a hundred and sixty thousand papers weekly, which, by a stamp on each paper, and a duty on advertisements, bring into the treasury of the nation upwards of eighty thousand pounds a year. They are to the English Constitution what the Censors were to those of ancient Rome. Ministers of State are checked and kept in awe by them, and they freely, and often judiciously, expose the pretensions of those who would harass government merely to be taken into its service."

Signor Lunardi makes his appearance at Court, and is presented at the drawing-room, which is very crowded, it being the anniversary of the King's coronation. The Prince of Wales is there, and laughingly congratulates him on being still alive.



AMONG THE CLOUDS.

CHAPTER III.

GLAISHER'S BALLOON ASCENT.

I PROPOSE to give a descriptive account of a journey through the air.

When it is intended to ascend five or six miles high, the balloon is but little more than one-half full; because gas expands to double its bulk at three and three-quarters miles high, and to three times its bulk at five or six miles; to fill the balloon before starting would therefore be to waste gas, and possibly annoy the occupants of the car by its escape by expansion at the neck of the balloon.

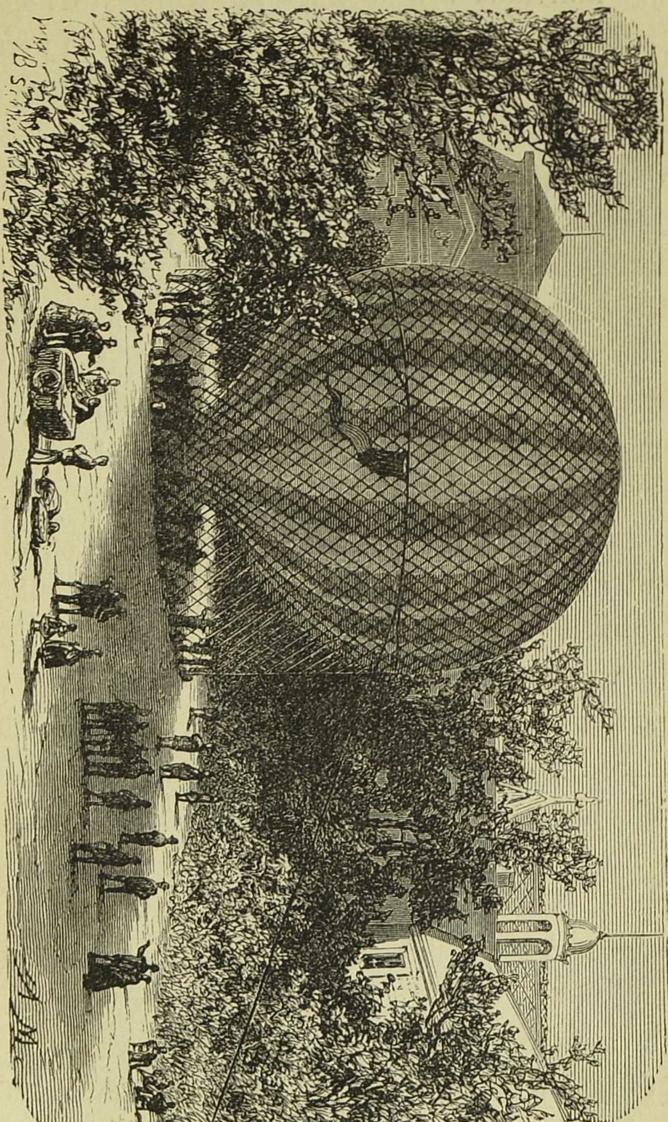
The processes of expanding and contraction are constantly going on, and vary with every variation in the height of the balloon. On passing from a cloudy state of the sky to a clear one, it is necessary to go through the clouds, during which time the cordage and the balloon become bedewed with moisture, so increasing its load; but on breaking into bright sunshine, the expansion from the sun shining on the balloon causes it to rise rapidly; two agencies being at work, viz., increase of heat and loss of weight by evaporation.

Imagine, then, the balloon somewhat more than half inflated, eager for flight, with only one link connecting it with the earth, viz., a rope attached to an instrument called a liberating iron or catch.

All the ballast, instruments, and everything else are placed in the car, with the grapnel attached outside, so as to be readily detached, and these amount to four thousand pounds. The balloon brought to a *nice* and *even* balance, so that the addition of twenty pounds would prevent it from rising, and its removal then would give it the required ascending power.

All, then, is ready, Mr. Coxwell, with his hand upon the catch, looks up at the sky, and is, apparently, staring at vacancy; but he is not. If the sky be partially cloudy, he watches till he is midway between the cloud that has passed and that which is coming, so that he may have a clear sky, and at least see the earth beneath, and avoid, if possible, passing through a cloud; for the cloud which preceded will always precede, and that which follows will always follow. Nor is that all; if he can start in a calm, he avoids much rotatory motion.

The favourable moment arrives; the catch is pulled, and we are free, but not only so, we are in profound repose; no matter how violent soever the wind may be,



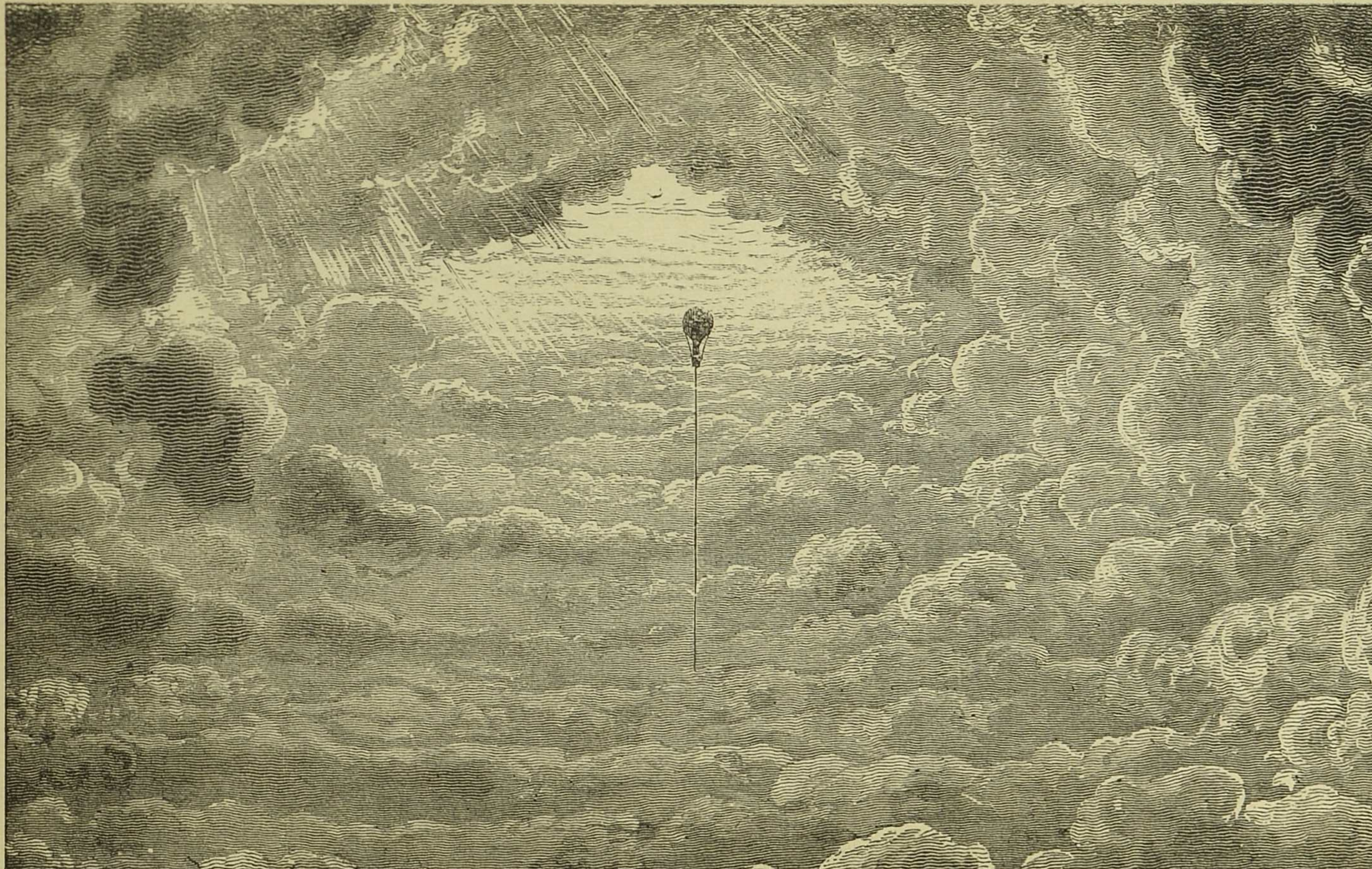
BALLOON PREPARING TO RISE.

no matter how agitated the balloon may have been sway ing to and fro, now on this side, now on that, with sudden and violent action, notwithstanding all the efforts of the many individuals who were struggling to hold it; all agitation in a moment ceases, and we are in perfect stillness, without any sense of motion whatever, and this continues throughout our entire flight.

Once away, we are both immediately at work; we have but little time for graceful acknowledgments to cheering friends. Mr. Coxwell proceeds to put the car in order, and accordingly looks to it, to his balloon, and to the course we are taking; and I must get my instruments in order. Without delay, therefore, I at once place them in their situations, adjust them, and take a reading as soon as possible. In a few minutes we are from one to two thousand feet high; Mr. Coxwell looks intently upwards, to see how the huge folds of the balloon fill into the netting.

If we have started from a town, its busy hum attracts our attention, and a glance shows us the many upturned faces in every street, and the town itself, which looks like an engineer's model in motion; and the now fast fading cheers of our assembled friends next attract our attention, and another glance shows us the quickly-diminishing forms of the objects we so recently left.

On approaching the clouds, Mr. Coxwell recommends me to take a farewell peep at the earth; and as I do this, the clouds receive us, at first in a light gauze of vapour, and then in their chilly embrace, where I examine their



BALLOON APPROACHING THE CLOUDS.

structure, and note the temperature of the dew-point particularly.

Shortly it becomes lighter, the light gradually increasing, till it is succeeded by a flood of light, at first striking, then dazzling; and we pass out of a dense cloud, to where the clouds open out in bold and fantastic shapes, showing us light and shade and spectral scenes, embellished with prismatic colours, disporting themselves around us in wild grandeur, till at length we break out into brilliant sunshine, and the clouds stretch away into a perfect sea of vapour, obscuring the earth entirely; then in the line from the sun passing us, we see the shadow of the balloon and car and ourselves upon the clouds, very large and distinct, with encircling ovals of rainbow tints; forming altogether a wonderful scene—a wonderful contrast to that of their lower surface.

When approaching the height of three miles, Mr. Coxwell directs my attention to the fact, that the balloon is full, and the gas is issuing from the safety-valve. He then directs my attention to the fit and proportions of the netting. I find the gas, which was before cloudy and opaque, is clear and transparent, so that I can look right up the balloon, and see the meshes of the network showing through it; the upper valve, with its springs and line, reaching to the car, and the geometrical form of the balloon itself. Nor is this an idle examination.

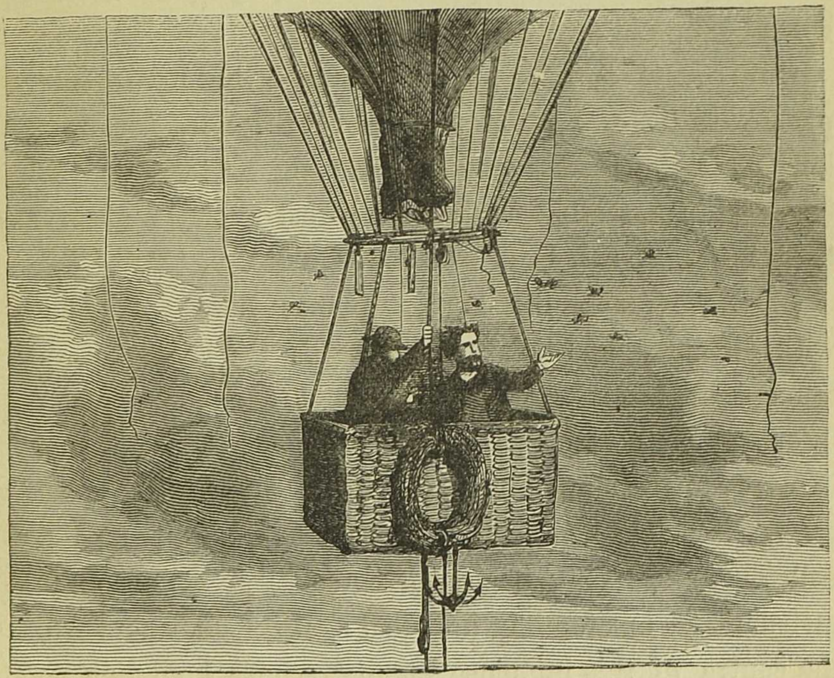
In passing through the cloud the netting would gather moisture, augmenting the weight of the balloon; if this should not all have evaporated, the network would have become frozen, and be as wire-rope; so that, if the diamond shape of the netting when under tension, and the form of the crown of the balloon, be not symmetrical, the weight might not be equally distributed, and there would be danger of it cutting the balloon. A sense of security, therefore, follows such an examination.

We are now three miles high. A stream of gas continually issues from the neck, which is very capacious, being fully two square feet in area, and which is always left open; and after a time I see Mr. Coxwell, whose eye has been continually watching the balloon, pass his fingers over the valve line, as if in readiness to pull the cord. I look inquiringly at him. He says, "The tension on the balloon is not greater than it would bear in a warm stratum of air with safety; but with a chilled balloon it is better to allow some escape at the top, as well as a good deal from the bottom."

We are now four miles high, and far beyond the reach of all ordinary sounds from the earth. A sea of clouds is below us, so dense that it is difficult to persuade ourselves that we have passed through them. Up to this time, little or no inconvenience is met with; but on passing now, much personal discomfort is experienced; respiration becomes difficult; the beating of the heart at times is audible; the hands and lips become blue, and at higher elevations the face also; and it requires the exercise of a strong will to make and record observations.

At five miles high, Mr. Coxwell counts the number of his sandbags, and calculates how much higher we can go, with respect to the reserve of ballast necessary to regulate the descent.

Then I feel a vibration through the car, and, on turning round, see Mr. Coxwell in the act of lowering the grapnel; then looking up at the balloon; then scanning



BALLOON SIX MILES HIGH.

the horizon, and weighing apparently in his mind some distant clouds, through which we are likely to pass in going down.

A glance suffices to show that his mind is made up how much higher it is prudent to rise, and how much ballast it is expedient to preserve.

We are six miles high, and now the balloon lingers, as it were, under the deep blue vault of space, hesitating whether to mount higher, or begin its descent without further warning. We now hold consultation, and then look around, giving silent scope to those emotions of the soul which are naturally called forth by such a wide-spread range of creation.

Our course is now about to change, but here I interpose with "No, no; stop; not yet; let us remain so long, that the instruments are certain to take up their true readings, so that no doubt can rest upon the observations here. When I am satisfied, I will say, 'Pull.'"

Then we reach the highest point; here we respire with difficulty, and talk but little. In the centre of this immense space; in solitude, without a single object to interrupt the horizon view for two hundred miles or more in every direction; abstracted from the earth; upheld by an invisible medium; a white sea below us; so far below, we see few, if any, irregularities. I watch the instruments, but forcibly impelled again, look round from the centre of this immense vacuity, whose bounding line is fifteen hundred miles, including an area of a hundred and thirty thousand square miles.

When I find no further changes are proceeding, I wave my hand and say, "Pull."

A deep resonant sound is heard overhead; a second pull is followed by a second report that rings as with shrill accompaniment down the very sides of the balloon. It is the working of the valve which causes a loud boom-ing noise, as from a sounding-board, as the springs force the shutters back. In that solitary region, amid a silence so profound that no silence on earth is equal to it, this sound strikes one forcibly.

It is, however, one sound only; *there is no reverberation, no reflection;* and this is characteristic of all sounds in the balloon, *one clear sound*, gone in a moment. *No sound* ever reaches the ear a second time. But though the sound from the closing of the valve in those silent regions is striking, it is also cheering, it is reassuring, it proves that the balloon is right.

We have descended a mile or more, and our feelings improve with the increase of air and warmth. But silence reigns supreme. Mr. Coxwell turns his back upon me, scanning the distant cloudscape, speculating as to when and where we shall break through, and catch sight of the earth.

On nearing the clouds we observe the counterpart of our own balloon reflected upon them, at first small in size, momentarily increasing. This spectral balloon is charming to look upon, and presents itself under a variety of aspects, which are magnified or diminished by the relative distance of our balloon from the clouds, and by its position in relation to the sun, which produces the shadow.

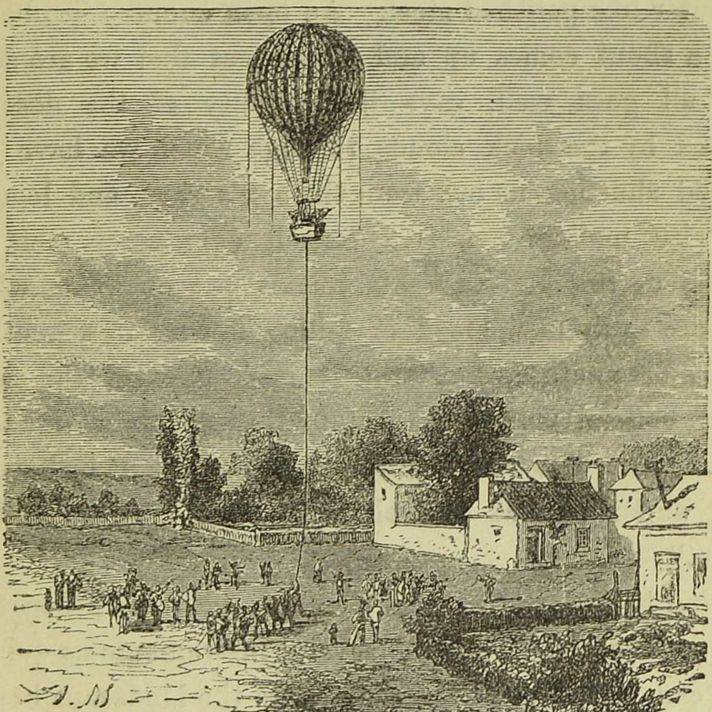
At mid-day, it is steep down, almost underneath; but it is more grandly defined towards evening, when the golden and ruby tints of the declining sun impart a gorgeous colouring to cloud-land. You may then see the spectre balloon magnified upon the distant cloud-tops, surrounded with three beautiful circles of rainbow tints. Language fails utterly to describe these illuminated photographs, which spring up with matchless truthfulness and choice decoration.

Just before we enter the clouds, Mr. Coxwell having

BALLOON DESCENDING TO THE CLOUDS.

made all preparations for the descent, strictly enjoins me to be ready to put up the instruments, lest, when we lose the powerful rays of the sun, and absorb the moisture of the lower clouds, we should approach the earth with too great rapidity.

In passing from bright sunshine into cloud, the gas becomes contracted by loss of heat, and the balloon every instant absorbs moisture and so increases its load ; both causes combining to make the balloon descend with great rapidity.



AT THE EARTH AGAIN.

We now near the confines of the clouds, see the spectral balloon approaching us, nearly as large as our own, and just then dip swiftly into the thickest of them. We experience a decided chill, and hear the rustling of the collapsing balloon, which is now but one-third full ; but cannot see it, so dense is the mass of vapour ; one, two, three, four, or more minutes pass, and we are still in the cloud; how thick it must be, considering the rapidity of the descent!

Presently we pass below, and the earth is visible. There is a high road intersecting green pastures; a piece of water like polished steel. An open country lies before us; a shout comes up and announces that we are seen, and all goes well, save the rapidity of the descent, caused by the thick clouds through which we have just passed shutting us out from the sun's rays, and loading us with moisture. Mr. Coxwell counteracts this by means of the ballast, and streams out one bag, which appears to fly up instead of falling down; now another, and still another, but still it goes up, till the wayward balloon is reduced within the bounds of moderation. Mr. Coxwell exultingly exclaims, "I have it now under perfect control, with sand enough, and to spare."

Glad to find the balloon checked, with the prospect of an easy descent, I read the several instruments as quickly as I can, noticing at the same time the landscape below, charming in its constant variation, rich with its mounds of green foliage, fields of various shades of green, intersected by roads, rivers, rivulets, &c.; and all this is seen with a distinctness superior to that on the earth; the line of sight is through a purer and less dense medium, everything seems clearer, though smaller. At the height of four miles over Birmingham, both Mr. Coxwell and myself distinguished readily the New Street station, and the several streets in the town, with the naked eye.

After descending slowly for a little time, Mr. Coxwell selects a spot for our descent, distant then two or three miles. The current near the earth, which is often stronger than the upper, wafts us merrily in that direction.

We are but a few hundred feet from the earth, when Mr. Coxwell requests me to put up the instruments, and he will keep on that level till I am ready. He throws out a little more sand, and I pack up the instruments in their wadded cases. Mr. Coxwell's eye is on the balloon, noting carefully the course it is taking with respect to the inclination of its descent on the spot where he has chosen to land. Shortly he calls out, "Are you all right?"

"All right!" I respond.

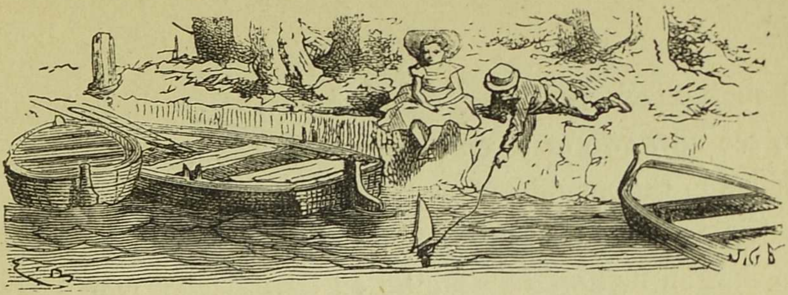
"Look out, then, and hold fast by the ropes, we'll stop in the large meadow, with the hedge-row in front."

Sure enough the grapnel catches in the hedge, and once again we are connected with the earth by one link. The valve line is drawn, and a little gas is allowed to escape.

The sheep, which have been watching the descending balloon, huddle together, and the cattle wildly scamper in all directions. Villagers break through the hedges on all sides, and we are soon surrounded by an agricultural crowd, some of whom take hold of the rope attached to the grapnel, and, as directed, pull us down, or hold it whilst we float to the centre of a field.

The valve is again opened, gas is allowed to escape by degrees, nothing is allowed to be touched till the reduced buoyancy of the balloon permits the removal of the instruments. The car is gradually lightened, till finally we step out, once more on the earth.

PAIN.



RAIN.

CHAPTER I.

SHOWERS AND WATERSPOUTS.

IT is not easy to believe that the showers which have just passed, leaving in that open water-butt in the yard only a gallon of water, and covering the bottom of it only an inch deep, have let fall a hundred tons into that kitchen-garden. Yet so it is, if only the bottom of the butt we speak of has a surface of four square feet, and the kitchen-garden is half an acre.

It is calculated that one inch of rain falling on an acre of land amounts to a hundred tons weight, and the same fall per square mile would give sixty thousand tons. So you may easily find out that as Great Britain contains 87,500 square miles, a rainfall over all this country equal to an inch of water would amount to 5,250,000,000 tons. Now suppose that quantity of water were to fall in one day, though much of it should sink into the earth, it is easy to see how two or three days' heavy rain can cause great floods in the neighbourhoods of rivers.

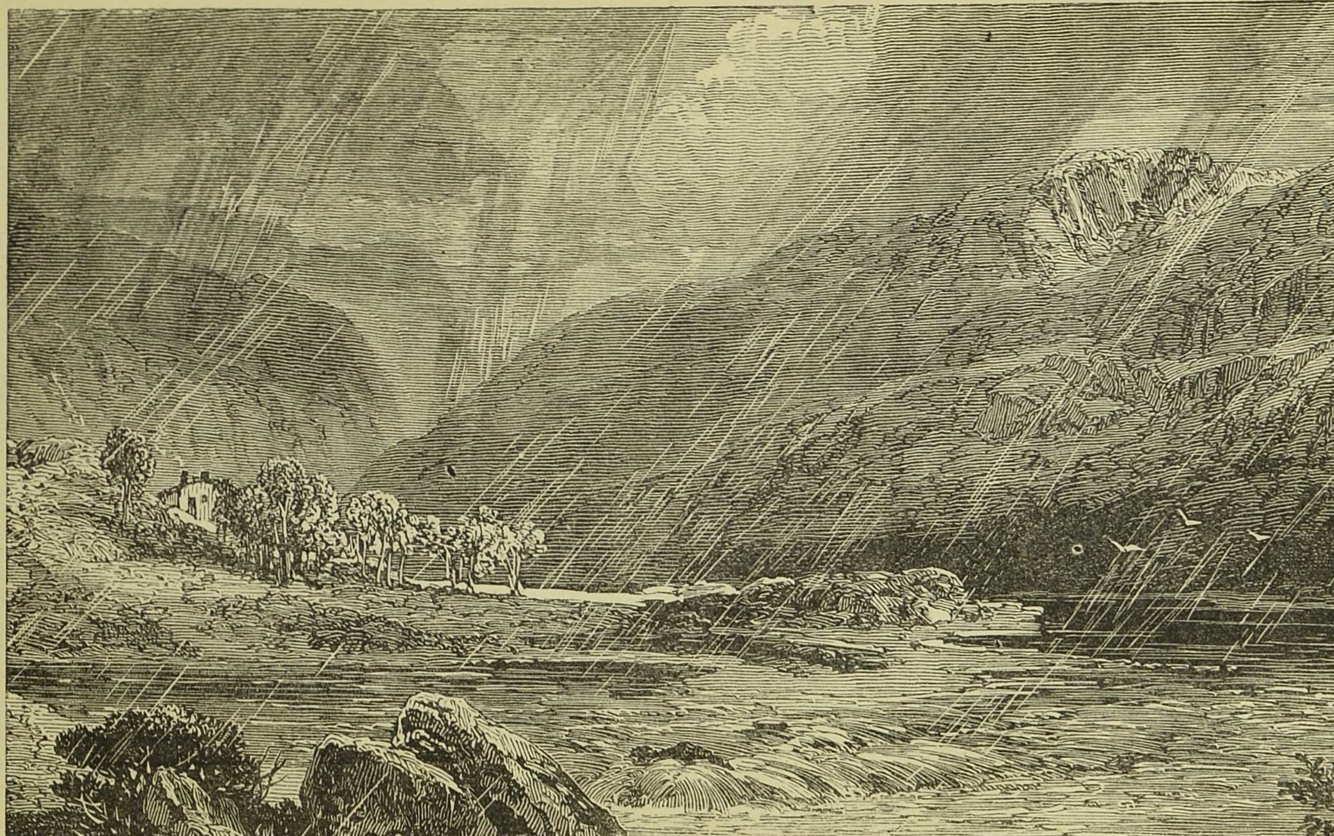
The area drained by the Thames is sixty-five square miles, so that an inch of rain falling on that district would give us four million tons of additional water, mostly finding its way into the river.

In some parts of the world and at certain seasons of

SHOWER.

the year such a rainfall would be considered as nothing. Our wettest weather is almost dry when compared with "wet weather" between the tropics. What, then, must be the rainfall over the whole world?

Whence comes the rain? and how does it come? Rain comes from the sky; but it is not made there, it is pumped there. The sun is the pump; it raises the water. The well is the sea, and the clouds are the aërial



RAIN-STORM.

tanks which it fills. Near the equator the pumping is chiefly done. The water is vaporised and rises into the air; there it is cooled, condensed, and forms clouds. In this form it is carried by winds to other parts of the globe, where it falls as rain.

Though tropical seas are the chief supply of rain, evaporation rises into the air from the surface of all waters, even from that of the Arctic ice-fields. The evaporation is invisible; when condensed it is visible, like steam coming out of the funnel of a locomotive. This so-called steam is not true steam, it is steam cooled; indeed, it is tiny drops of water called "bubble steam." Clouds are "bubble steam." It is little drops which form clouds.

No doubt it strikes you as strange that rain-water in a tub is quite transparent, whilst rain-water in a cloud is what is called opaque, that is, cannot be seen through. This difference is caused by the water in one case being in one mass and in the other in many tiny particles. A very similar difference may be seen in a sheet of glass whole, and the same crushed into fragments and gathered into a heap. Every particle of the heap is transparent, but the heap itself is opaque. So it is with water in sheets, and the same in tiny particles floating in the sky.

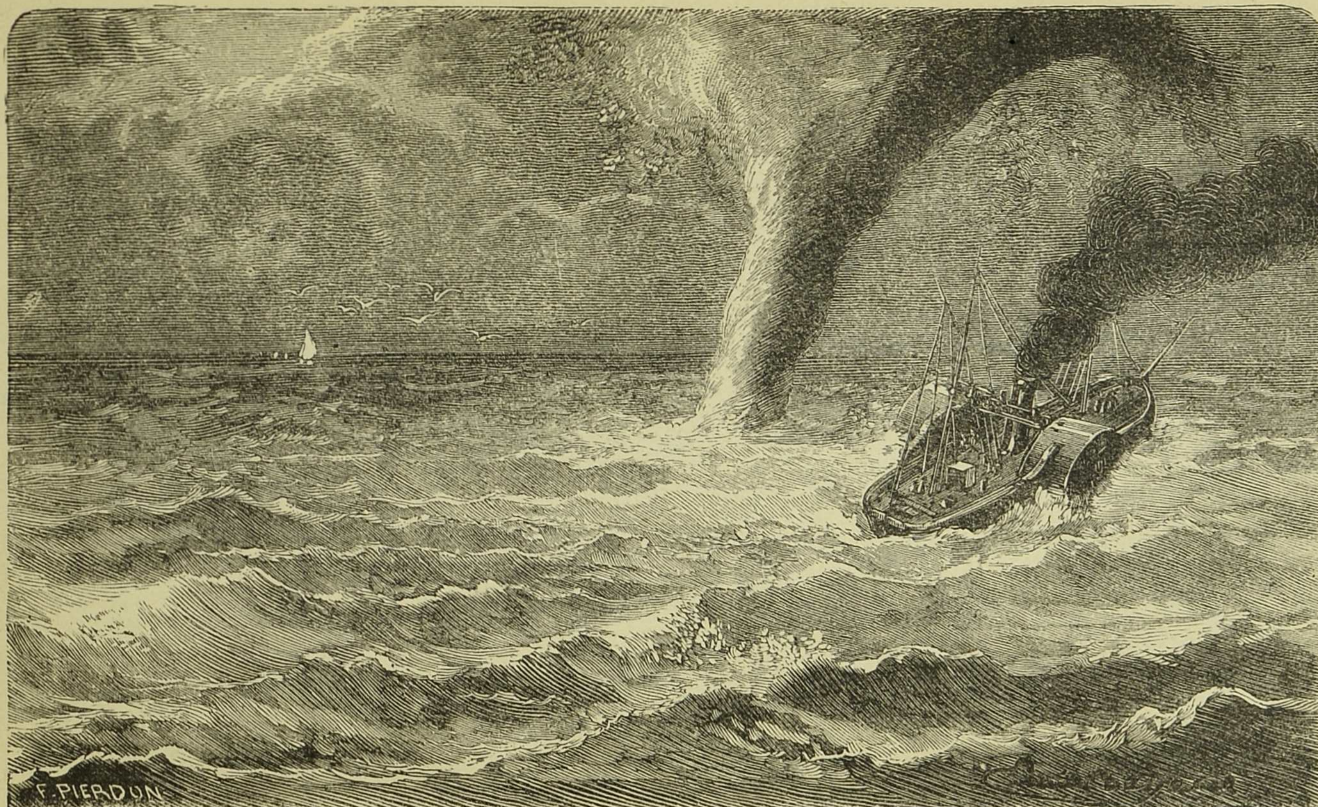
The reason why we call the sun a pump is that the sun heats and dries the air, and heated air may be compared to a sponge. Over water it becomes a full sponge, which remains full until some power like the human hand squeezes it dry again. This squeezing power is cold. Let the heated air lose its heat, and down sinks the steam into vapour; let it lose still more, then down sinks the vapour into rain. The imaginary sponge is squeezed; it is dry again and ready for future use.

Now this atmospheric sponge is no small thing. It is the atmosphere of the whole globe up to a height of about five miles. To give the dimensions of the sponge in figures, we must speak of thousands of millions of cubic miles. When any part of it is raised to a temperature of 80°, every superficial acre of it contains a thousand tons of water.

The wettest region of the world is a place north-east of Calcutta, where the total annual rainfall amounts to fifty feet. Now as an inch of water over one mile of area weighs sixty thousand tons, on every mile of that locality there falls every year no less than thirty-six million tons of rain. But what renders this fact still more remarkable is, that it all falls in six months of the year.

But this sky-vapour does not always return to the globe in showers; one curious method is what is called the waterspout.

A waterspout is a column of water apparently resting on the sea and supporting the cloud. Those who have witnessed its origin say that first some cloud, usually a very black one, projects from its centre, in form something like an inverted sugar-loaf. This projection appears to revolve. Gradually it lengthens, its point nearing the sea. Then immediately under it a second and similar form rises from the sea, its point being in a direct line with the



WATERSPOUT AT SEA.

point of the first. Both the cone above and the cone below are in violent revolution; with their revolution they increase in bulk and length, till with an electric flash they meet and form a pillar of water. The pillar thus formed is not stationary, it still whirls round its own centre, and it also travels across the sea.

The danger of a waterspout at sea is when it bursts, which it often does with terrific violence, overwhelming everything near it. A ship is in this manner sunk in a moment, giving no opportunity of escape to a single soul on board. By one such calamity five vessels were all at once sunk in the harbour of Tunis.

In stormy weather they form, break, and vanish with great rapidity, several being visible at one time. When a waterspout forms close to a ship, a cannon is fired in the hope that the disturbance of the atmosphere will break the column, and thus disperse it whilst it is far enough away to save the ship.

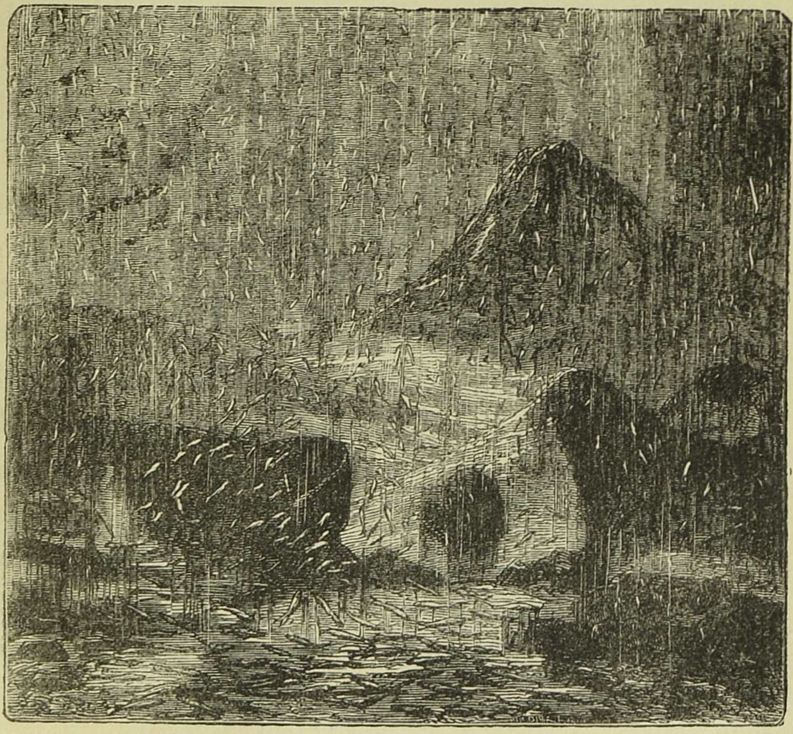
Waterspouts are imagined (for knowledge we are still without) to be caused by electrical influence happening to act on the water and the clouds at the same time and place. There are what may be called inland as well as sea waterspouts. Sometimes these are dropped from the clouds on dry land where no water can meet them, and sometimes they meet the water of some lake or river.

One of the exclusively cloud waterspouts occurred near Calcutta, and was calculated to be about fifteen hundred feet high. In half a minute it burst, covering half a square mile with water to about six inches deep. Waterspouts of this kind, as you may imagine, are of enormous force, and have great power of destruction. In the summer of 1798 one occurred at Ramsgate, where it flooded several cellars to the depth of four feet. In 1806 one burst over the Wheal Abraham and Crenver mines in Cornwall and choked up the shaft, causing considerable destruction of property and the death of several miners. In 1807, another, consisting of a torrent of water nearly six feet in diameter, descended upon the town of Silkstone in Yorkshire, and several of the inhabitants were drowned. In 1838, a waterspout of very destructive character overwhelmed the village of Kingscourt, Ireland. These were all purely cloud waterspouts.

Sea waterspouts are seldom seen in British waters. One, however, occurred in the Channel off Brighton in 1864. It lasted about a quarter of an hour, and dispersed without damage. Its duration was attended with thunder, and on its breaking up a heavy hailstorm swept over the locality.

The electrical theory of the origin of waterspouts is supported by the electric flash that accompanies the union of the descending and ascending columns, and by such associations as those of the Channel spout seen off Brighton.

Showers are not always of mere water. It would seem as though by waterspouts, or by some other method, young aquatic life is occasionally carried up from the sea into the air, where, stranger still, it appears to find for a time at least a suitable home. The *Caernarvon Herald*, of 1833, says that on the edge of Lake Gwynant, in the county of Caernarvon, a woman was engaged washing a pail, a number of children with her. While she was thus employed, at eight P.M., a shower of small fishes fell partly into the lake, partly upon the land close



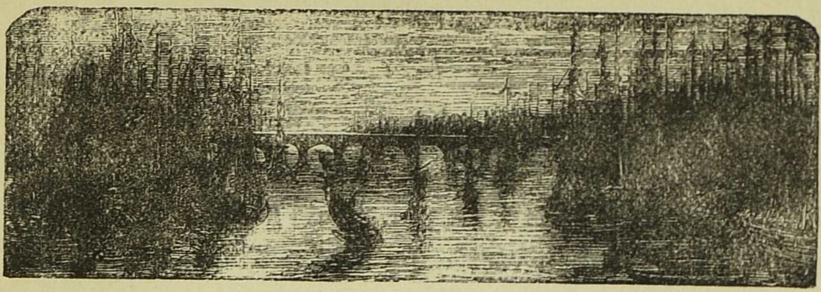
SHOWER OF FISHES.

to where she stood. The fish resembled very small herrings. The newspaper which records this fact does not say that they were alive.

"Yesterday morning," says an American newspaper of 1835, "a great number of small fish were found swimming in the gutters in Jefferson Street, Louisville. During the previous night a heavy rain fell, and the fish of course descended with the water. We saw a number of them; they were from two to three inches long, and were mostly sun-perch."

In Reid's "Law of Storms" it is retold that on the 9th of March, 1830, the inhabitants of the island of Isla, Argyleshire, after a day of heavy rain, were surprised to find a number of small herrings strewed over their fields, perfectly fresh, and some of them exhibiting signs of life.

Another account of a similar kind is given in Hasted's 'History of Kent." About Easter, says the writer, in the year 1666, in a pasture-field in the parish of Stansted, which is a considerable distance from the sea and from any branch of it, a place where there are indeed no fish-ponds, there were found fish in quantity about a bushel, supposed to have been rained down from a cloud, there having been at that time a great tempest of thunder, hail, wind, &c. These fish were about the size of a man's little finger; some were small whiting, others like sprats, and some rather like smelts. Several of these fish were shown publicly at Maidstone and Dartford.



RAIN.

CHAPTER II.

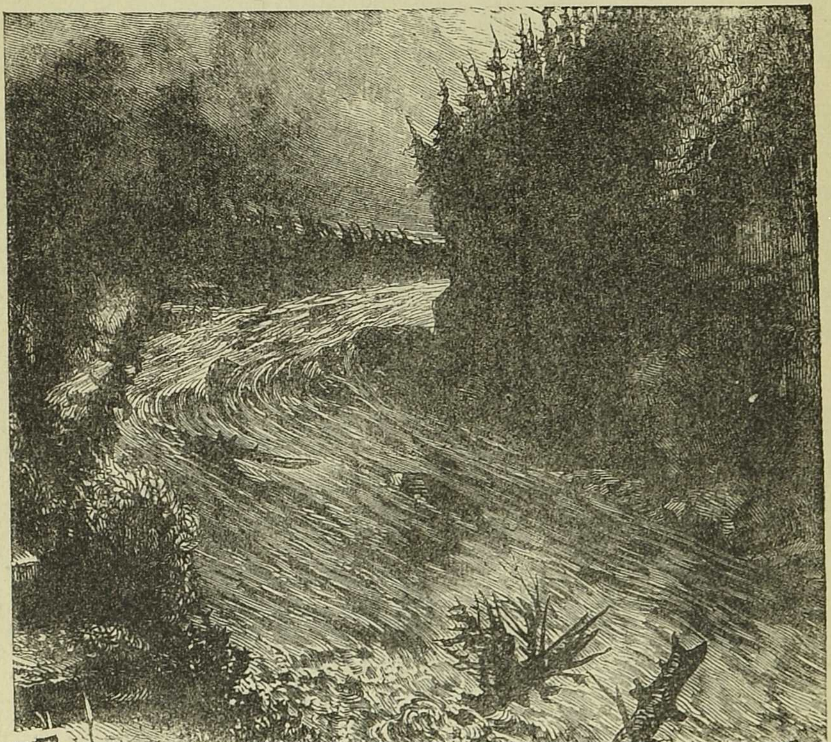
MUD-TRAINS.

IF we follow the falling shower we shall find that sooner or later every drop, yes, literally every drop, finds its way back again into the vast sea from whence it came.

Much rain goes up into the sky again in the form of mist or vapour, and some sinks into the earth to rise again in springs, to be drunk and then evaporated through the skin.

But the greater part of rain works its way by several tiny channels into tiny brooks; many of these meet together, form torrents and streams, which at length produce a river, and every one of the water-courses is a waggon in a train which is carrying from the land through which it passes mud, gravel, and sand out into the sea.

All water-courses are, in fact, trains—mud-trains—removing the dry land, softened into mud, to the bottom of the sea. When there has been much rain the train is heavily ladened. Mud, sand, and gravel are carried away swiftly and in vast quantities. The work of these



RAPIDS ON AMERICAN RIVER.

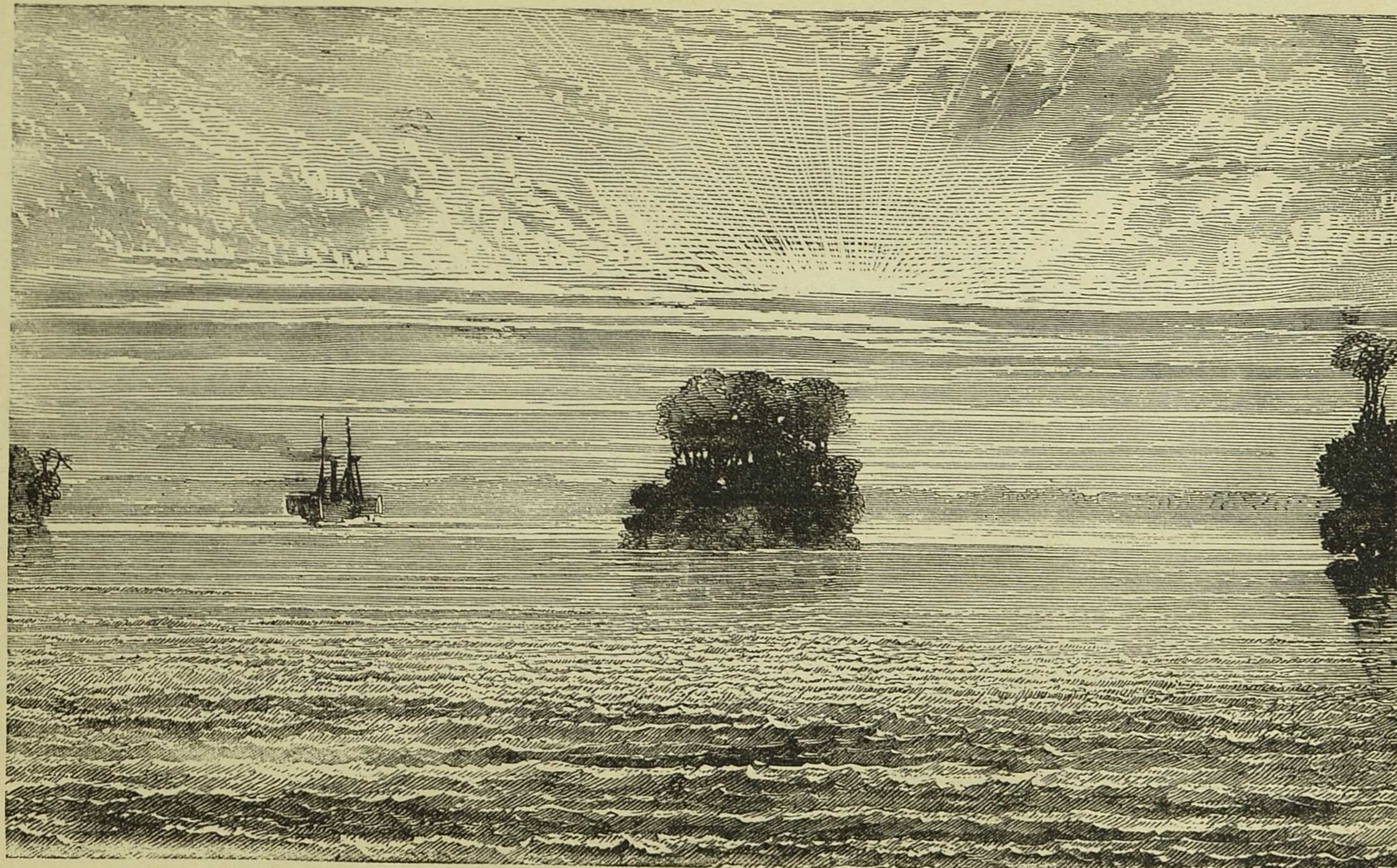
rainfall trains is more than the work of all steam trains on every railway of the world.

Look at the length of some of these trains. The Mississippi in North America is 4,424 miles long; its basin contains hundreds of thousands of cubic miles. This river has carried down from the land and emptied near to its mouth what covers twelve thousand three hundred square miles, from five to six hundred feet deep. In this immense "tip," as railway people would call it, is

LAND WASHED AWAY BY RAIN.

found shrubs and trees of almost every kind and size. It has been calculated that the mud, sand, and gravel which every year are carried by this river and are thrown into the sea at its mouth, amounts to 3,700,000,000 cubic feet. A cubic foot is a solid block, the shape of a square box, having four sides, a top, and a bottom, each of which measures twelve inches every way. This is the work of only one of the world's mud-trains.

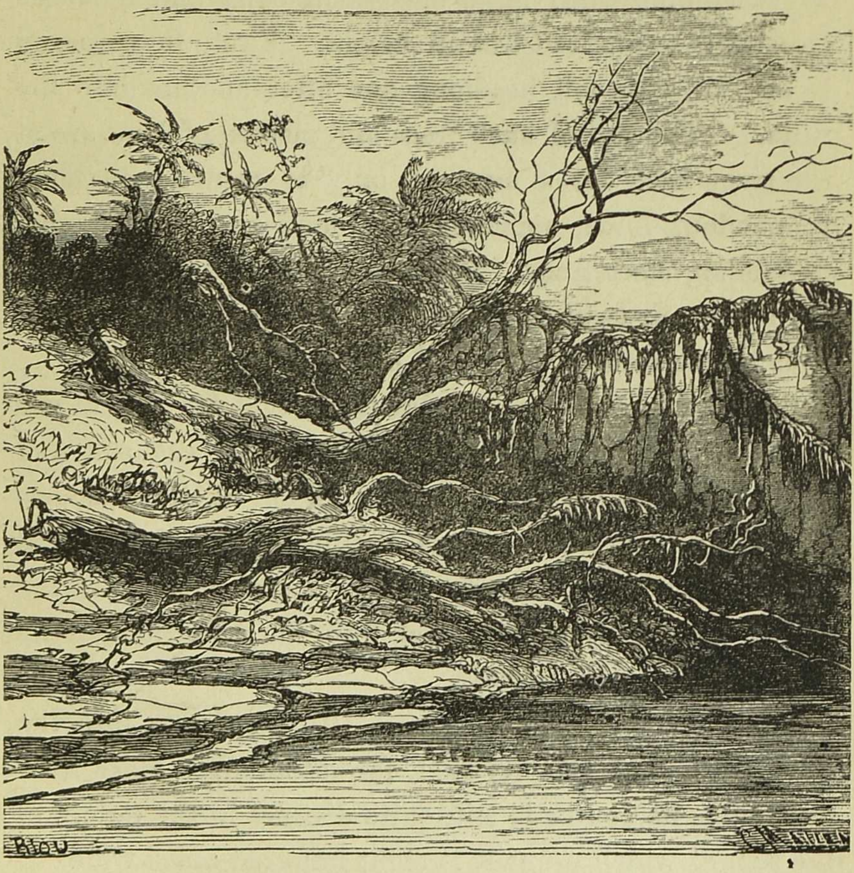
Look at another. The Ganges, in India, when flooded during the four months of the wet season, is estimated to carry down every *second* eight hundred thousand cubic feet of water, which carries with it solid matter to the amount of eight hundred cubic feet. In a hundred and twenty-two days of rain the discharge of sediment was no less than ten thousand million cubic feet. The grand total of mud carried down by this one mud-train in its special and ordinary service every year into the sea is about eleven thousand million cubic feet. The quantity of mud thus carried through the Ganges by rain-fall would raise one foot high, a surface of nearly four hundred square miles. Were the mud dried it would weigh five hundred and forty million tons. You have, perhaps, seen pictures of the pyramids of Egypt. Well, then, this river-train carries down every year to the sea the weight of no less than ninety pyramids of granite. According to a calculation made by the great geologist, Sir Charles Lyell, if a fleet of more than eighty Indianmen, each freighted with about fourteen hundred tons weight of mud, were to sail down the river every hour of every day and of every night for four months, they would only transport from the higher country to the sea a mass of solid matter equal to that borne down by the Ganges in the four months of the rainy seasons.



ISLANDS FORMING AT THE MOUTH OF THE AMAZON.

We might give similar particulars of the Amazon. How this train receives its enormous cargo is described by the naturalist Bates.

A heavy fall of rain had taken place on the high lands



FALLEN TREE, WITH RIVER DEBRIS, SHOWING HEIGHT OF RIVER IN FLOOD.

where streams fed the river. Of this fact, however, he had no knowledge until the consequences were visible where he was. About sunrise he was aroused by sounds as of firing artillery. The night was calm, but the cause was manifested in the agitated, swollen state of the river. It continued to swell and its roll became terrific. It left its banks and swept into the forest, carrying in its overwhelming whirl large masses of bank and immense trees of two hundred feet in height. First, they rocked to and fro, then fell headlong one after another into the water. The fall of such trees and masses of land swept the river back for a moment, only to return with more tremendous force, sapping more land and undermining and felling more trees. This busy destruction was visible for a mile or two, but how far it reached it was impossible to conjecture. It lasted some hours.

So great is the force of this train, that far out at sea the river-water is almost unmingled with the salt and its current hardly altered. Even here, at the distance of three hundred miles from the mouth of the river, it moved at the rate of nearly three miles an hour, carrying such a large body of sediment into the Atlantic that its muddy colour was visible.

The River Plate, another vast stream, shoots into the ocean with such velocity that, for six hundred miles from its mouth, its course is still quite distinct in the waters of the sea, at which point it is eight hundred miles wide.

Such rainfall scenes as the above account for the immense masses of wood and soil which are found in some rivers, that are indeed worthy of the name they have—floating islands. One mass in a branch of the Mississippi was ten miles long, two hundred and twenty yards wide, and eight feet deep. It was covered with bushes and trees and a variety of flowers: some of its trees were sixty feet high. Some trains tip their contents too soon. In the Red River a mud-bank has been formed, till young willows and cotton-wood trees have sprung up on it.

It is impossible to form any idea of this railway work of the rain on its way to the sea, through the streams, brooks, and rivers of the world. Its busy drops are forming new islands and continents, which one day will rise from their hidden depth, and become the bright and busy homes of vegetable, animal, and human life.

FROST AND SNOW.

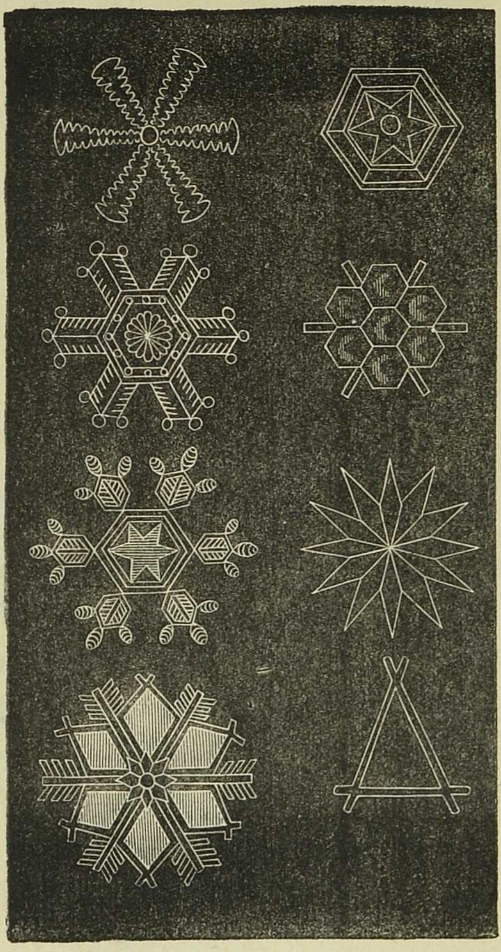
FROST AND SNOW.

CHAPTER I.

THE SNOW-FLAKE AND THE AVALANCHE.

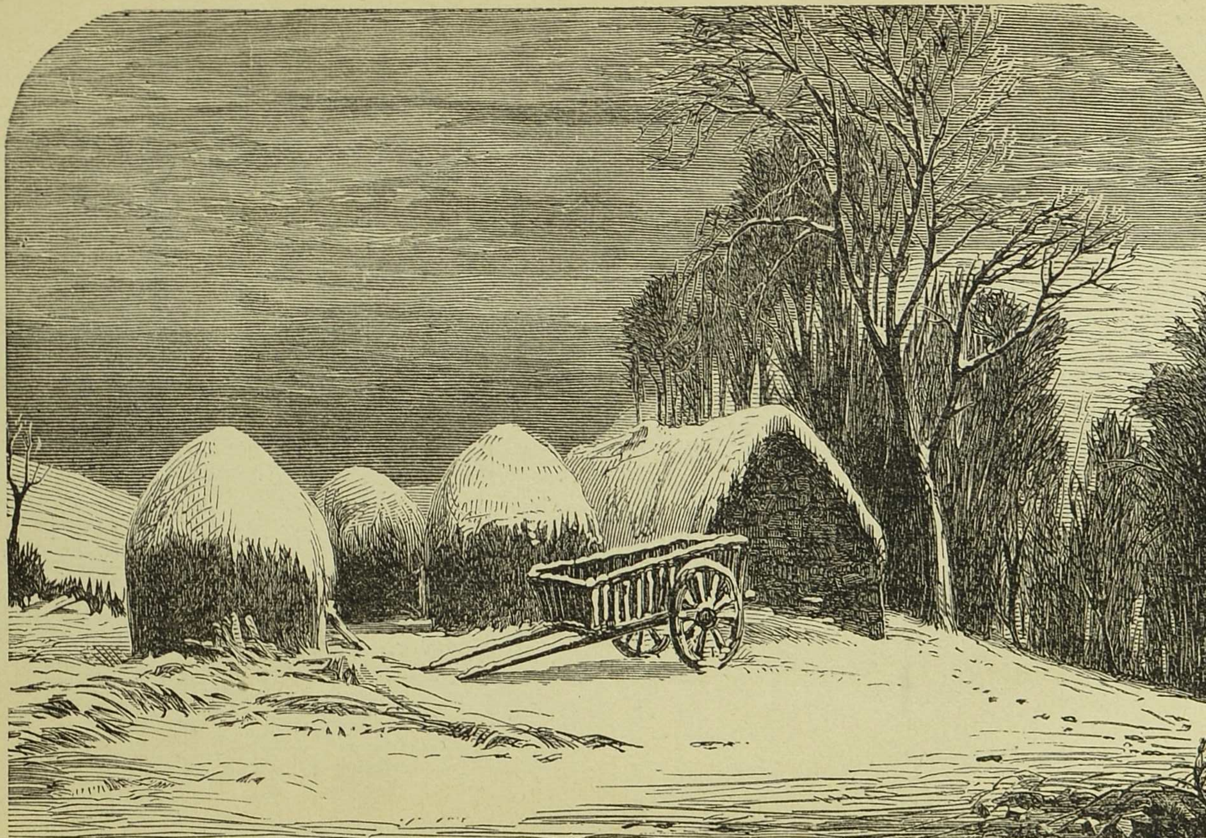
THE Scythians reported to Herodotus of the country lying beyond them, "that it could neither be passed nor yet discerned with the eye, on account of the feathers which were continually falling. With these both the earth and the air were so filled as effectually to obstruct the view." In history we read of a whole nation talking of snow in the same way. Many of the Queen's subjects in their own country never see snow, and to them no description of a fall of it is so natural as a shower of feathers. This is the description given in the nursery rhymes.

But the wonder of a fall of snow is not that it is "a shower of feathers;" but that it is a shower of crystals. And how is this? Snow is produced by the freezing of moist vapours which arise from the earth and are suspended in the atmosphere. Its flakes are made to assume the most elegant and regular forms, which are called



SNOW CRYSTALS.

crystals. The name crystal is applied to all matter which takes a definite geometrical form. These crystals



BEAUTIFUL SNOW.

are of great variety of shape, and all are of great beauty. Of a few of these we give an illustration, and the number of other forms having the same marvellous symmetry and delicacy is almost countless.

It is only in such extreme cold as that of the Arctic regions that all the wonders of snow crystals are to be found. In the severe winters, however, our own snow presents, though not the same lavish variety of form, yet each of the still many forms is of equally wonderful beauty. Dr. Glaisher has represented one hundred and fifty of these snow figures which he had observed during a single winter. The majority consists of thin six-sided plates, star-shaped. Sometimes these are surrounded by other similar forms; but the variety of these crystal forms is indescribable. Every fall of snow brings new forms, or forms previously unobserved, all alike symmetrical and marvellous.

Let us now hear a beautiful and poetical description of the many effects of a fall of these delicate forms :—

"Surely, of all things that are, snow is the most beautiful and the most feeble. Born of air-drops, less than the fallen dew, disorganized by a puff of warmth, driven everywhere by the least motion of the winds, each particle light and soft, and falling to the earth with such noiseless gentleness that the wings of ten million times ten million make no sound in the air, and the footfall of thrice as many makes no noise upon the ground, what can be more helpless, powerless, harmless? But not the thunder itself speaks God's power more than this very snow. It bears His omnipotence, soft and beautiful as it seems! While it is yet in the air, it is lord of the ocean and the prairies. Ships are blinded by it. It is a white darkness. All harbours are silent under this plushy embargo. The traveller hides. The prairies are given up to its behest, and woe to him that dares to venture against the omnipotence of soft-falling snow upon these trackless wastes! In one night it hides the engineering of a hundred years. It covers down roads, hides bridges, fills up valleys. It forbids the flocks to return to the fields. The plough cannot find its furrows. Towns and villages yield up the earth and obey this white diffusive despot.

"Then, when it has given the earth a new surface, and changed all vehicles, it submits itself again to the uses of man, and becomes his servant, in its age, whom it ruled and defied in the hour of its birth. But, when flake is joined to flake, and the frosts within the soil join their forces to the frost descended from the clouds, who shall unlock their clasped hands? Who shall disannul their agreement? or who shall dispossess them of their place? Gathered in the mountains, banked and piled till they touched the very clouds again in which once they were born and rocked, how terrible is their cold, and more terrible their stroke, when, slipping, some avalanche comes down the mountain side, the roar and the snow-stroke loud as thunder and terrible as lightning! God gives to the silent snow a voice, and clothes its innocence and weakness with a power like His own."

The above alluded to the power of snow in the avalanche—the tremendous peril of travellers in the Alps.

Avalanches are banks of snow which have fallen upon the edge of a precipitous rock. Sometimes these banks have been melted by the sun and then frozen into masses of ice. These immense banks suddenly leave the rock on which they rest, and slip and leap down the mountain side. It only requires a gust of wind, or even only its own weight, to loosen it. The snow-bank, ten thousands of tons in weight, as it rolls down its headlong way, like a boy's rolling snowball, gathers size and weight till it crushes into the valley beneath, surprising its inhabitants—often, alas! burying them and their cattle and dwellings beneath its enormous mass. Our full-page illustration is of the arrival of this terrible Alpine visitor at a small farm. In its way down into the valley it destroys everything; it uproots or snaps off large trees, it meets the pine-forest and makes it like a field of mere stubble, till at length farm, men, and cattle are about to be buried by it—buried never to be restored. Such misfortune occurs mostly in winter and in early spring.

In 1720, a Bernese Oberland village, with eighty-four persons and four hundred head of cattle, was in this way entirely destroyed. A village in the Grisons has more than once been partially destroyed from the same cause.

In summer, the danger is removed from the valley to the mountain passes. Here the mountain traveller, merely by the sound of his own voice, may set them in motion. The sound of their coming is described as a soft "hiss," or like a prolonged speaking of the word "hush."

By these mighty yet silent engines of destruction many a journey of pleasure has been changed into the journey of death. In a moment, the unsuspecting traveller has been conducted to the land from which no traveller returns.

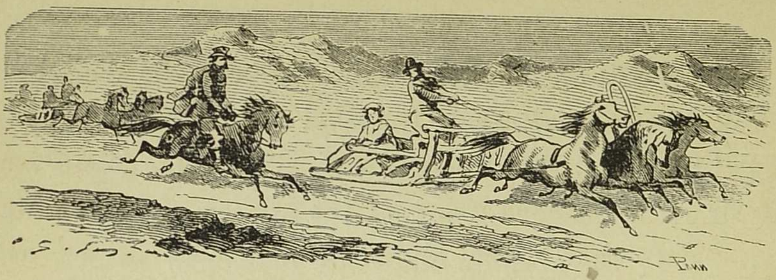
It is not uncommon to find in many of the Alpine passes a memorial cross marking the spot where, in this way, a life has been lost.

Occasionally these tremendous sights may be seen from a place of safety. This is the case on the northern face of the Jungfrau, where they fall in all their sublimity, and are viewed without the least risk. The face of the mountain is here one thousand feet high, and down this the immense mass leaps. The crashing thunder of their fall is repeated again and again by the echoes. This is preceded and followed by the sound of the fall of smaller fragments, which on the whole has the effect of a sharp rattle of a long rolling fire of musketry, in the middle of which twenty cannon are simultaneously fired.

One fragment of the ice of these avalanches which fell in the Lower Grindlewald measured ten feet long, eight feet high, and six feet wide, and contained four hundred and eighty cubic feet of ice. The effect of the falling of the largest avalanches is somewhat like that of a gunpowder explosion. In the winter of 1819-20 a large ice

THE AVALANCHE.

avalanche fell off the steep eastern slope of the Weisshorn, fifteen hundred feet above the level of the valley. Though it did not touch the village itself, yet, by the mere blast of air its fall caused, most of the houses of Rauda were levelled to the ground, and roofs and large beams were blown to a distance of more than a mile.



FROST AND SNOW.

CHAPTER II.

ICE AND HAIL.

FEW things are more wonderful than the power of the air when its temperature is cold enough to freeze.

Everybody knows that frost hardens water into a solid mass called ice; and everybody knows that when frost gives place to a warmer temperature the ice melts, and the water again becomes fluid. But everybody does not know that whilst water is freezing it expands, nor do they know that the expanding water will have its way; that if it is contained in a vessel which does not gracefully allow it room to expand, it will take room by force —it will burst the vessel, be it of cast-iron or solid rock. So is accounted for that common winter occurrence in our homes, the bursting of a water-pipe, so generally attributed to the thaw. The thaw simply releases the water, and permits it to run through the rent which the formation of the ice had already made. The thaw reveals the burst, but the frost bursts.

Illustrations of the tremendous power of frost-expansion are found in two experiments of an artillery officer at Quebec, made during a severe winter. In the first, the officer took a bomb-shell, about fourteen inches in diameter, filled it with water, then closed up the opening with an iron peg, driven firmly in. In this condition he exposed the shell to the severe frost. At length the stopper with a loud noise was driven out more than a hundred yards away, and a cylinder of ice, eight or nine inches long, shot up through the opening. Then he tried a second shell in the same way, this time driving in the iron plug more firmly. The plug remained in its place, but then the expansive force of the ice split the shell itself!

So you see that the effect of frost on water is slowly what the effect of a lighted match is on gunpowder quickly. But it is more. To houses situated on wet land it has been like a lever, raising and overthrowing them. To rocky mountains it has been like a wedge, entering at some water-charged crack, splitting away a thousand ton weight, and hurling it into the abyss below.

Hailstones! These are the children of the frost. But Where are they made? and How?

Professor Dove has suggested that a grain of sleet first formed at a great height in the air may make several revolutions in an inclined whirlwind, and during its passage through cold and hot strata alternately obtain that shell of ice which covers the grain of sleet in the centre, until it becomes so heavy that at last it falls to the earth.

This theory would account for the noise which generally precedes a heavy hailstorm, and which is due to the rotating motion of the hailstones before they fall.

So thinks the Professor, but he does not profess to know; he only makes a clever guess, and he supports his guess by saying:—

"The edges of the whirlwind seem to favour the formation of hail, in consequence of the fact that the circles described by the hailstones are largest, and consequently the difference of temperature which they have to pass through is greatest."

But be this theory true or not, as it may, hailstorms are facts, and sometimes very terrible facts too.

The size of hailstones varies greatly, and although some of considerable dimensions occasionally fall in England, those which fall in India are (at least, according to Dr. Buist) from five to twenty times larger, and often weigh from six ounces to a pound. It is difficult for Englishmen to credit Dr. Buist when he adds that these stones are seldom less than walnuts, and often are as large as oranges and pumpkins! When these fall the storms are almost always accompanied by violent wind and rain, and by thunder and lightning.

Some hailstorms in our own country have been very remarkable. In April, 1697, one passed over Cheshire and Lancashire, the course of which was two miles broad and sixty miles long, and which sent down hailstones weighing eight ounces, and measuring nine inches round. On the 4th of May in the same year, a shower of hail fell in Hertfordshire after a thunderstorm, the hailstones measuring fourteen inches round, and killing several persons.

It is curious that on the 4th of May, 1797, that is, exactly a century afterwards, another hailstone was seen in Hertfordshire which measured fourteen inches in circumference.

Several hailstones of these uncommon dimensions may be forced together so as to form aggregates, which should be regarded as masses of stones rather than single ones. A hailstone which measured nineteen inches round fell near Birmingham in June, 1811, and was plainly a union of stones about the size of pigeons' eggs. In the summer of 1815, during a thunderstorm at Malvern, in Worcestershire, hailstones fell as large as walnuts, and in some places to the depth of several inches.

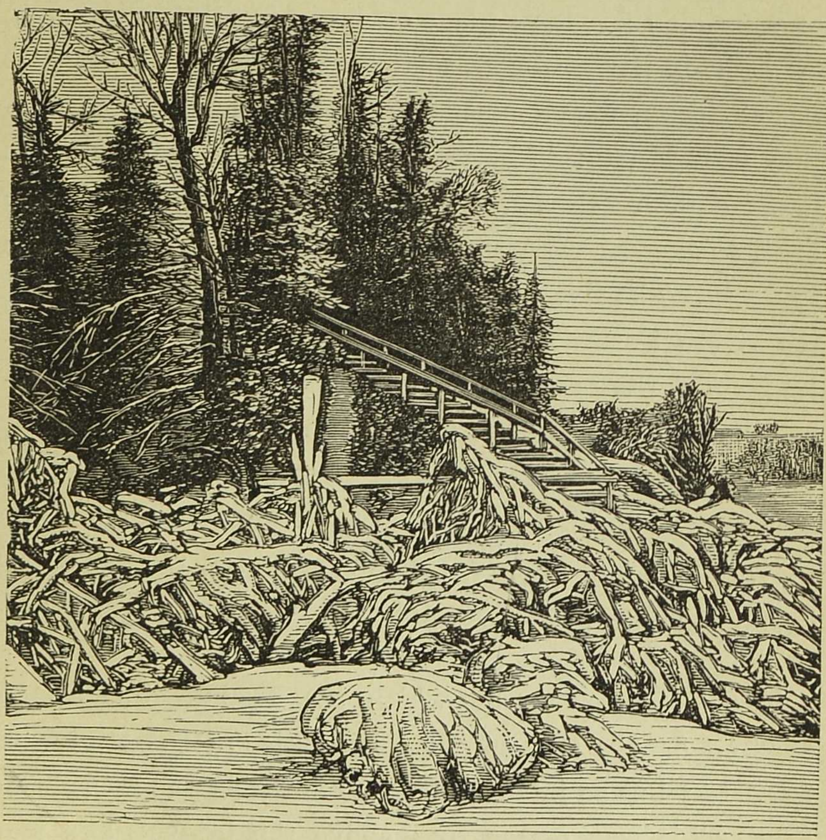
But hailstorms are not always of hailstones—that is, of the round well-known form. In August, 1828, pieces of ice fell at Horsley, in Staffordshire, some of which were three inches long and one broad. In 1826, a mass fell in Candeish which must have weighed more than one hundredweight, and which was some days in melting. In 1832, a lump fell in Hungary of no less than a yard in length and nearly two feet in thickness; and if we can credit the account printed in the *Ross-shire Advertiser*, there fell in August, 1849, a block of "irregular shape, nearly twenty feet in circumference," on the estate of Mr. Moffat, of Ord, immediately after an extraordinary loud peal of thunder. This mass is said to have been composed of lozenge-shaped pieces from one to three inches in size, firmly frozen together.

The formation of such solid masses in the air is not yet explained. Until it is, we must with wonder accept the fact.

The destructive force of hailstones is owing to the height from which they fall, and consequent speed; probably also to the whirling momentum imparted by the rotatory winds which accompany them. One of the most appalling hailstorms on record was that of the 1st of August, 1846, when hailstones weighing from one to two ounces fell in London, and destroyed a great amount of property in Buckingham Palace, Westminster Hall, and other buildings, while the loss suffered exclusively by gardeners was estimated at £15,000.

Frost most easily arrests standing water, such as pools and lakes, but in its greatest severity it binds flowing streams.

In the winter of 1063, the Thames was frozen over for fourteen weeks. In the winter of 1433-4, from below London Bridge to Gravesend, it was frozen from November 24th to February 10th. In 1515, carriages passed over from Lambeth to Westminster. In 1607, so strong was the ice that fires were lighted on the river, and all sorts of diversions were carried on. In 1684, the frost was so severe, that nearly all the birds perished; the ice of the Thames was about a foot thick, and a fair was held upon it, at which there were printing-presses that struck off verses and inscriptions commemorative of the event. What is more indicative



RIVER BANK IN WINTER.

of the terrible power of that winter's frost, large masses of ice appeared that year in the Channel, and it was reported that between Dover and Calais it was within about a league of joining.

Again, in 1715-16, the Thames was ice-bound; the ice is said to have broken up and to have been piled everywhere in hillocks frozen into huge rocks of ice. Huts, stalls, and printing-presses were once more erected on it; again the ox was roasted, and all the festivities of a London fair took place on it. But all was not fun; for London navigation was stopped, coals rose to £3 10*s*. per chaldron, which means in that day much more than that sum to-day. Shipping was damaged to the value of £100,000. Ducks, widgeons, and coots perished with cold, or starved for want of food; even fish were frozen to death. The rivers Severn, Lyne, the Avon, by Bristol, the rivers Forth, Tay, &c., in Scotland, and the Liffey, by Dublin, were all frozen up like the Thames. Throughout the whole of Europe that winter's frost laid its hands on everything with severer and more prolonged grip than men remembered, or than it has since done. In some parts bears and wolves, mad with hunger, ranged about in open country and broad day, devouring men and cattle.

The last occasion on which the Thames was frozen over so deeply and so far down was in the winter of 1813-14; but so late as what is known as the "Crimean Winter" it was frozen over above the bridges, and ice-blocks, like little bergs, were piled ten and fifteen feet high, some of which, being stranded on the banks at the thaw, did not melt until far on into May.

But in England the tyranny of frost never attains its most tremendous power. In Canada, during its ordinary

SEA DRIVE—GULF OF BOTHNIA.

winter reign, work must cease. The agriculturist is compelled to be idle, navigation is bound, and commerce suffers a blockade. Universal holiday is its decree. Vast lakes it throngs with skaters, who travel great distances. Wheeled carriages disappear from the roads and

SLEIGH ON RIVER.

streets, and the sleigh, in every variety of form, takes their place. The sleigh drive is the most delightful sensation of the year. The rapid pace, the smooth and noiseless motion, the bright sunshine, the joyous excitement of the horses, the bracing atmosphere, all combine to refresh and exhilarate, and many are the hearts which, for the sake of sleighing, cry, "Long live King Frost!"

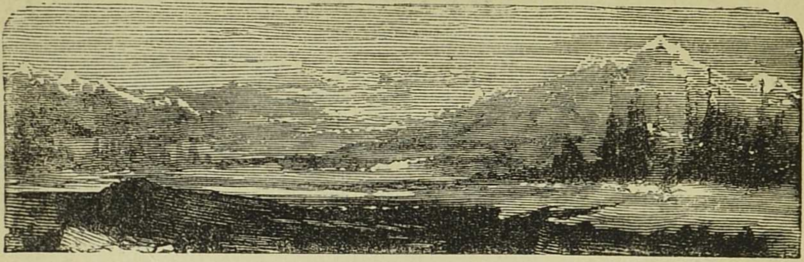
But not so everybody; for old King Frost is not a merry old soul to all Canadians.

"The cold of the Canadian winter," says Sir Francis Head, speaking of that part of the country where he lived, "must be felt to be imagined, and, when felt, can no more be described by words than colours to a blind man or music to a deaf one. Even under bright sunshine, and in a most exhilarating air, the biting effect of the cold upon the portion of our face that is exposed to it resembles the application of a strong acid, and the healthy grin which the countenance assumes requires—as I often observed on those who for many minutes had been in a warm room waiting to see me—a considerable time to relax. In a calm almost any degree of cold is bearable, but the application of successive doses of it to the face by wind becomes occasionally almost unbearable. Indeed, I remember seeing the left cheek of nearly twenty of our soldiers simultaneously frost-bitten in marching about a hundred yards across a bleak, open space, completely exposed to a strong and bitterly cold north-west wind that was blowing upon us all.

"The remedy for this intense cold, to which many Canadians and others have occasionally recourse, is—at least to my feelings it always appeared—infinitely worse than the disease. On entering, for instance, the small parlour of a little inn, a number of strong, ablebodied fellows are discovered holding their hands a few inches before their faces, and sitting in silence immediately in front of a stove of such excruciating power that it really feels as if it would roast the very eyes in their sockets."

Railway engines, so many as run, are obliged to carry in front snow-ploughs for clearing the rails, but often snow-drifts suddenly come upon trains, and are frequently so deep, that sometimes three or four engines have to come to the rescue, and with their united strength tug the buried train through them. Not unfrequently the "tug" fails; the train cannot be moved; then all the passengers have to leave the train as best they can, seek in some neighbouring farm shelter and food, and wait and hope for a better day. With the slightest wind these "drifts" come pouring over the edge of a cutting, like sand pouring down from a sand-glass.

In both Canada and Russia, frost transforms the rivers into the high roads, along which much of the travelling is done, and in both countries the sleigh takes the place of wheeled vehicles. On the Gulf of Bothnia, sleighs not unfrequently become the winter ships, and by them voyagers cross from shore to shore. Every reader is familiar with the character of the Arctic region—that Paradise of Frost!



FROST AND SNOW.

CHAPTER III.

ICE-RIVERS.

IT is very difficult, I know, for young people to understand how ice, and much more how soft snow, should have such strength that it can grind whole mountains into plains.

You have never seen ice and snow do harm, they are to you mere playthings; and you long for winter, that you may make snowballs, and play hockey, and skate upon the ponds, and eat ice, like a foolish boy, until you make your stomach ache. And I dare say you have said, like many another boy, on a bright, cheery, ringing, frosty day, "Oh that it would be always winter!"

You little knew for what you asked. You little thought what the earth would soon be like if it were always winter—if one sheet of ice on the pond glued itself on to the bottom of the last sheet, till the whole pond was a solid mass—if one snowfall lay upon the top of another snowfall till the land was covered many feet deep, and the snow began sliding slowly down the hills into the glen, burying the green fields, tearing the trees up by their roots, burying gradually house, church, and village, and making this place for a few thousand years what it was many thousand years ago. Good-bye, then, after a very few winters, to bees, butterflies, singing-birds, and flowers; and good-bye to all vegetables, fruit, and bread; good-bye to cotton and woollen clothes. You would have, if you were left alive, to dress in skins, and to eat fish and seals—if any came near enough to be caught. You would have to live, in a word, if you could live at all, as the Esquimaux live now in Arctic regions, and as people had to live in England ages since, in the times when it was always winter, and icebergs floated in our seas. Oh no, my child! thank Heaven that it is not always winter, and remember that winter ice and snow, though it is a very good tool with which to make the land, must leave the land year by year, if that land is to be fit to live in.

I said that if the snow piled high enough upon our hills, it would come down their glens in a few years, and then you would have a small glacier here—such a glacier (to compare small things with great) as now comes down so many valleys in the Alps, or as come down all the valleys of Greenland and Spitzbergen, till they reach the sea, and there end as cliffs of ice, from which great icebergs snap off continually, and fall and float away, wandering southward into the Atlantic for many a hundred miles. By the picture you may judge

SNOW-LAKE.

for yourself how you would like to live where it is always winter.

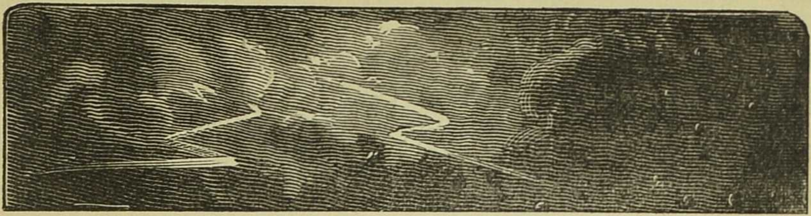
Now what does a glacier mean ? Why, a glacier is only another name for a river of ice fed by a lake of snow. The lake from which it springs is the eternal snow-field which stretches for miles and miles along the mountain tops, fed continually by fresh snowstorms falling from the sky. That snow slides off into the valleys hour by hour, and as it rushes down is ground and pounded and thawed and frozen again into a sticky paste of ice, which flows slowly, but surely, till it reaches

THE ICE-PLOUGH.

the warm valley at the mountain foot, and there melts bit by bit. Ice-rivers are enormous powers—they are Nature's great ice-ploughs, to plough down her old mountains, and spread the stuff of them about the valleys to make rich strata of fertile soil. The mountain lakes in Europe and in North America have been scooped clean out of the solid rock by ice-rivers which came down in old times. So you see that there are rivers which are always frozen, not of water frozen over, but rivers of solid ice.

Ice-rivers descend into the valleys, down the sides of most snow mountains; they cut out valleys and grind down mountains into plains. The rate at which these ice-rivers move is always slow. In summer one of them has moved thirty inches a day. One in the Alps is two miles broad and sixteen miles long, and falls eight thousand feet. There is one in the Himalayas from two to three miles wide and thirty-six miles long.

ELECTRICITY.



ELECTRICITY.

CHAPTER I.

THUNDERSTORMS.

EVERYBODY has heard the story of Franklin, in 1752, flying his kite during a thunderstorm, and drawing sparks from a key tied on the end of the string. Franklin used this plaything, not for play, but for science. It was by this means that he discovered that thunder was caused by electricity. It required a great deal of sense to make such a good use of a kite.

More sense than even every enterprising spirit has, for Franklin was not the only one who experimented with a thunderstorm ; one of those who followed his example did so at a great price. Professor Richman, at St. Petersburg, had erected an apparatus for experimenting on the question. He saw a thunderstorm coming on, went home, and on entering his study went over to the conductor of the machine, when a ball of fire leaped to his head, and he fell dead to the ground. So don't you be trying experiments with kites, or anything else, and thunderstorms, lest you bring unwillingly a ball of fire from the sky, and your friends should find you, as Richman's friends found him, poor fellow! Thunderbolts are dangerous playthings! Electricity is at all times diffused through the atmosphere.

Lightning is this atmospheric electricity brought into a continuous strain. Artificial lightning is produced by effecting this concentration of electricity. Mr. Crosse, who had a number of electrical conductors erected in his park in the west of England, says that during a severe storm he has observed "a continuous stream of fire" passing from the knobs at the end of his machine. This was lightning on a small scale.

A flash of lightning differs only from the spark obtained from an electrical machine in the amount of its force. Its course is uncertain, but it chiefly seeks such things as are good conductors of electricity, as metals and water, avoiding non-conductors. When a flash has passed through a body which is only just short of a perfect conductor, the smallest possible hole or mark is made visible, although in other parts of its course the same flash may have shivered a tall tree or the mast of a ship.

Whenever we see lightning flash in a line, it is called "forked." The electricity finds its way along the particles of air, just as in the experiment of Mr. Crosse it found it along the metal wire. As the particles of air are transparent, we can see the blaze of the electrical current, which we could not in the case of the wire. The reason for the zig-zag of the line is this. Electricity follows the line in which the nearest particles of air afford it the readiest passage, and these particles happen to lie in a zig-zag line. Sheet lightning is only the reflection of

FRANKLIN EXPERIMENTING WITH HIS KITE.

lightning at such a distance that the lightning itself cannot be seen, nor the thunder heard.

Lightning in its passage causes sound—a single sound, as of an explosion. This is the origin of thunder, which has a prolonged rolling sound that dies away. The cause of the rolling is the echo of the clouds.

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The apparent interval between the flash of lightning and the commencement of thunder has been known to vary, in different cases, from less than a single second to between forty and fifty seconds; on very rare occasions it has exceeded fifty seconds.

One of the rare and curious accompaniments of electrical storms is globular lightning, or balls of fire. They present a very remarkable appearance, and are known to be of the nature of lightning from the damage they have inflicted on ships or buildings struck by them; but they differ from ordinary lightning not only in their shape, but by their slow motion and the length of time during which they are visible. Sometimes they occur, as has been reported, without the accompaniment of a storm, and even under a perfectly serene sky.

Thunderstorms are brought on by a wind blowing in one direction in the higher regions of the air, and in another direction in the lower, the upper one being more heavily charged with electricity. Thunder-clouds, therefore, appear to come up against the wind, but it is only against the wind which we are feeling. They are moved by another and contrary wind, which blows above that. Thunderstorms do not occur equally in all parts of the world.

In this country we are visited by them at intervals during most years; but in the high latitudes of the northern and southern hemispheres they are almost wholly unknown, and it is believed that over the ocean in the middle latitudes, when distant from continents, they are of very rare occurrence. On the other hand, there are localities where, during certain months of the year, they are of daily occurrence. In the Port Royal Mountains in Jamaica, about the hour of noon, from the middle of November to the middle of April, they occur every day.

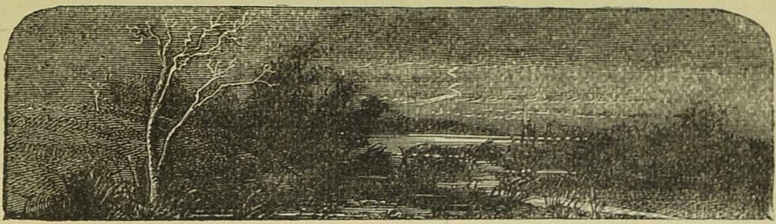
Though lightning courses wildly through the air, yet it

FORKED LIGHTNING.

may be caught and conducted quietly and safely, even down the side of a house, into the ground beneath.

A good lightning conductor must be of metal, and be so placed as to rise high above the highest point of the building, and must run down in unbroken metallic connection to the earth, or to running water, presenting to these the greatest possible number of points, so as to favour the escape of electric fluid.

When the metallic conductor is of sufficient thickness and properly placed, lightning will not quit it. The conductor may lie directly upon wood or stone, or may pass through water, or even if a man should grasp it with his hand, yet will the lightning not leave it. It passes through a perfect conductor without leaving, and without leaving on it even a single trace of its passage. Even though gunpowder may be placed around a metallic conducting-rod, the passing lightning will not kindle it. Yet let the conductor break off, so as to require the passage of the electric stream through the air, even for the shortest distance, a spark would flash and the powder explode. Hence good conductors are perfect protectors, even to a powder magazine.



ELECTRICITY.

CHAPTER II.

THE AURORA BOREALIS.

"ONE thing," said the wise King of Israel, "is set over against another," that is, Every disadvantage has some advantage going with it. Thus the long months of darkness in northern regions are relieved by the glories of those grand celestial illuminations known as the Aurora Borealis, or Northern Lights.

These sights are in great variety. The common signs of their coming are: first, the hue of the whole sky deepens, forming an arch of the darkest hue away towards the north. Sometimes, after this, and from the centre of the dark arch, quivering fires begin to flash, multiplying their numbers, increasing their length and brilliancy, until that dark arch is one glittering radiance of light rays. At other times the form of the aurora is that of a vast phosphorescent cloud, which rises and falls and breaks into tongues of flame. When this palpitating glory reaches its height it passes description. Neither of these classes—silver radiance and the crimson clouds—are entire strangers to our English winter nights. The English visitors are, however, not at all equal to their northern relatives in vivid magnificence. There is a third, and to us altogether unseen form. Instead of brilliant rays or crimson clouds, the lights have the effect of an immense fringe of fire, hanging in graceful folds from the arch of the firmament. The colour is principally red, but it is shot with various bright and changing hues.

The aurora or northern light in our latitudes usually presents itself at first as a dingy fog, drooping on and over the northern horizon, and generally rather brightest towards the west. This fog gradually assumes the shape defined by the string and wood of a bow more or less bent. The upper part of the bow is surrounded by a white light, occasionally broken up into one or two distinct luminous arcs. Out of the fog shoot gorgeous streams and flashes of all colours, and it is torn into fragments which flash incessantly from dark to bright and from bright to dark. It appears to be thrown into a condition of violent trembling and palpitation. When the aurora is at all considerable, we easily detect, in spite of the constant shifting of every individual, that all the beams converge towards the zenith, where a superb auroral crown is formed. The phenomenon is not commonly of long duration, and is, of course, in the night.

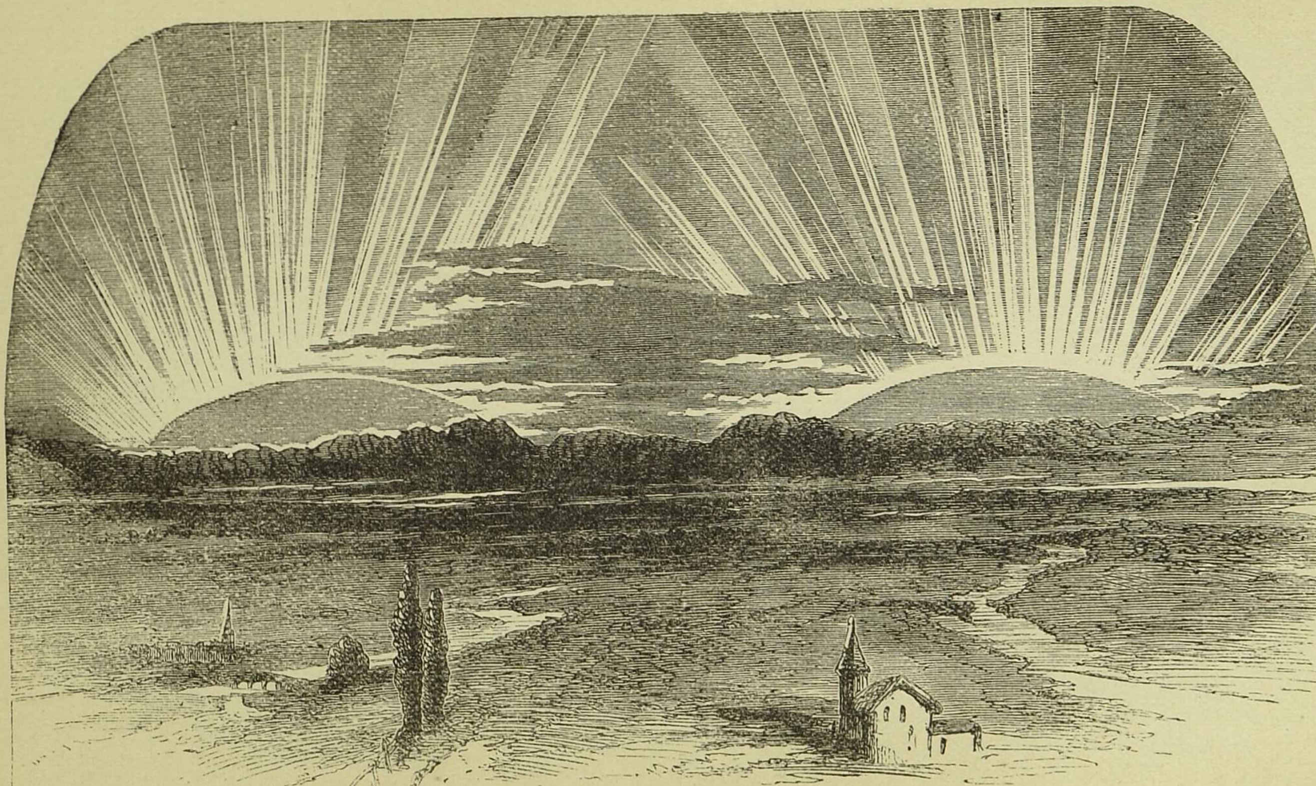
As it diminishes in splendour, the crown shifts its position to the right and left, and the arrows of light become feebler and altogether cease, dropping back into the mass of the obscure fog in the horizon, which itself sensibly

RAYED AURORA BOREALIS.

diminishes, becoming, however, feebly luminous as it disappears.

This wonderful phenomenon is doubtless due to electricity. When the aurora is being displayed, the magnetic needles are agitated, and currents of electricity rush from the air into the telegraph lines, agitating the dial needles. It is said that during an aurora display the telegraph line in one part of the United States was kept in a state of agitation for hours. It is an interesting, and, when we are able to understand it, it will probably turn out to be a very instructive, fact, that the rays of an aurora always appear to leave one pole for the other. We give an illustration of a remarkable aurora seen at Amiens, and quote a description from the pen of an eye-witness.

On October 12th, about seven in the evening, there was, says our authority, a magnificent aurora borealis at Amiens. A remarkable light, in some places of a vivid red, spread over a large portion of the sky, in spite of the presence of the moon and of numerous clouds which partly interfered with complete observation of the phases of the phenomenon. Towards the north, the horizon about the time mentioned was covered with thick *nimbi*. Below these there were long streams of red light mixed with rays of a whitish colour, which shot out at intervals of from five to ten minutes in the direction of the magnetic meridian to the altitude of Vega in the constellation of the Lyre. At the same time an immense sheet of ruddy light unrolled itself like a vast banner to the west. The eastern arch was neither of nearly the same brightness nor so clearly defined—no doubt because of the moon which was shining at the time in all its splendour



DOUBLE AURORA BOREALIS.

in that part of the sky. This continued altogether about twenty minutes. The western arch was still brilliant at 8.45 P.M.

Between these two arches there was a wide dusky interval filled with masses of clouds, which gave a character of indefiniteness to the lower part of the aurora. At the moment of greatest brightness, the entire luminous portion spread over a space of more than a third of the horizon. At this time the brilliant rays darted, as we have said, almost up to the zenith, and were grouped in sheaves of four or five together, red and pale alternately. These sheaves of light would flash all at once with the most dazzling colours, which lasted two or three minutes; the bands would then appear to fade away. In a few minutes after the same splendour started back again.

During all this display, there were extraordinary irregularities in the working of the electric telegraph. The needles moved spontaneously in the most extraordinary ways. At many of the telegraph stations they gave out electric sparks. In one, the thing went beyond a joke, where a telegraph clerk had an unforeseen electric shock which paralyzed his arm. Sentences of grim nonsense, and collections of consonants, unpronounceable in any language, were spelt out laboriously that night before the astonished telegraph clerks when they tried to send a message or receive one. Utterly meaningless messages, which came from nowhere, were received everywhere.

Unfortunately, there were few scientific men present to register and interpret these eccentricities, or question Nature, caught in the fact of such extraordinary manifestations, by the Baconian method of torture. But we do know that the wires of the telegraph contain electricity in current, just as the magnetic needle contains that fluid (we call it so only to fix our ideas) in a state of rest. It is the property of electrified bodies to be powerfully influenced by any others in their neighbourhood.

So putting the aurora and the telegraphic disturbance together, we are left in the general conclusion of the electric origin and nature of auroras.

Fortunately, in about two days the instrument returned, after this unwonted exhilaration, to their ordinary condition.

Other theories than the electrical have been propounded to explain the aërial glories.

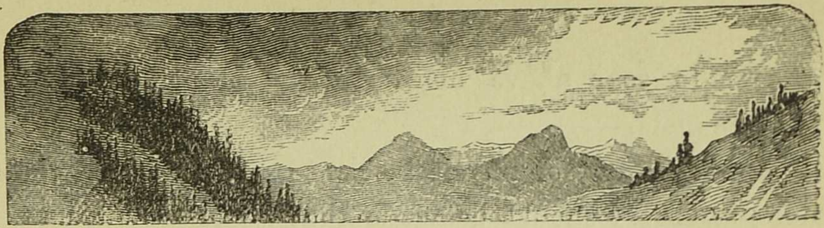
Sir John Ross, the well-known Arctic voyager, believed that the aurora borealis was, to use his own words, occasioned "by the action of the sun, when below the pole, on the surrounding masses of coloured ice, by its rays being reflected from the points of incidence to clouds above the pole which were before invisible." Sir John tried by artificial means, in harmony with this theory, to produce it. He placed a powerful lamp to represent the sun, having a lens, at the focal distance of which was placed by him a rectified terrestrial globe, on which he placed bruised glass of the various colours he had seen in Baffin's Bay. These represented the coloured icebergs of that locality, while the space between Greenland and

Spitzbergen was left blank, to represent the sea. To represent the clouds above the pole which were to receive the refracted rays, he applied a hot iron to a sponge, and by giving the globe a regular diurnal motion he produced the phenomenon vulgarly called "the merry dancers," and every other appearance, exactly as seen in the natural sky, while it disappeared as the globe turned.

During his last voyage to the Arctic regions (1850-51), he said that he never among the numerous icebergs saw any that were coloured, but all were a yellowish white, and during the following winter he observed that the aurora was exactly the same colour. When that part of his globe was covered with bruised glass of that same colour, the phenomena produced in his experiment was exactly the same as the aurora australis in the Antarctic regions, where neither coloured icebergs nor coloured aurora are seen.

That auroras are the result of electrical force is, however, beyond doubt. Advancing knowledge will probably make clear and simple the working of the great cause, and thus add to the glories of sight the higher glories of intelligent appreciation.

A JOURNEY THROUGH SPACE.



A JOURNEY THROUGH SPACE.

CHAPTER I.

THE VEHICLE AND THE START.

THE immensity of the universe as contrasted with our world is difficult to realise, though the facts and deductions of astronomy bring it out sufficiently.

We can do this best if in fancy we escape from the narrow confines of our globe, and see it, and the system of which it is a part, from a different stand-point. Let us take a nearer view of other orbs and systems, and see what impressions they produce, as compared with that received from the platform of the earth.

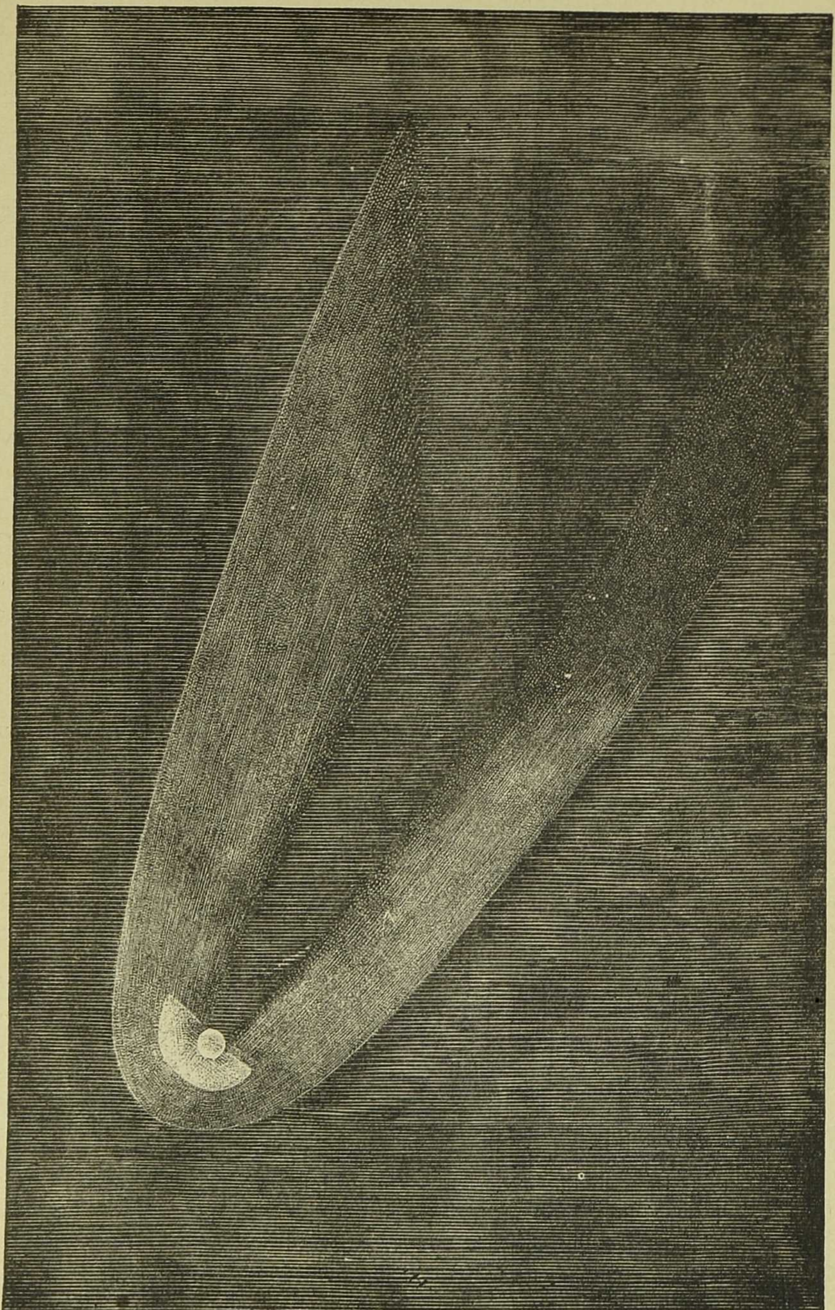
But what vehicle can we avail ourselves of for our excursion? Must we be altogether dependent on the fairy wings of imagination, or can we derive aid from some less ethereal agencies? It was long the fond wish of man to soar above his terrestrial scene, and visit other planets.

In the infancy of physical science, it was hoped that some discovery should be made that would enable us to emancipate ourselves from the bondage of gravity, and, at least, pay a visit to our neighbour the moon. The poor attempts of the aëronaut have shown the hopelessness of the enterprise. The success of his achievement depends on the buoyancy of the atmosphere, but the atmosphere extends only a few miles above the earth, and its action cannot extend beyond its own limits.

The only machine, independent of the atmosphere, we can conceive of, would be one on the principle of the rocket. The rocket rises in the air, not from the resistance offered by the atmosphere to its fiery stream, but from the internal reaction. The velocity would, indeed, be greater in a vacuum than in the atmosphere, and could we dispense with the comfort of breathing air, we might with such a machine transcend the boundaries of our globe, and visit other orbs.

Instead, however, of torturing our imagination to conceive of a rocket device, which would eclipse the performances of all flying machines, let us take one of nature's rockets as the material aid to our imaginary flight. Let us follow the course of some comet in its wanderings across our system.

A rocket, held fast with its fiery stream directed against a strong wind, very well represents the telescopic



HEAD OF COMET.

L

appearance of a comet when in the neighbourhood of the sun. The luminous particles shoot out from the nucleus of the comet precisely as the sparks issue from the rocket-tube, and they are thrown back as a strong wind would throw back the fiery stream of the rocket. The sector or fan, so well seen in the comet, is the form which the gush of luminous particles assumes under some unknown repelling power. The revolution of the comet is determined by the laws of gravitation; but there are perplexing movements in the tail and nucleus of the comet, which likely will receive an explanation from this rocket-like action.

We have, however, to do at present, not with the theory of the constitution of the comet, but with its character, as a vehicle for surveying the universe. The densest comet would afford but insecure footing to beings of almost spiritual essence, as the matter of which it is composed must be so light that the atmosphere of our earth is as lead compared to it. But we shall overlook this difficulty, and venture, in thought, to follow the fortunes of some wandering star.

The great advantage of the comet as a convenient vehicle for an excursion is, that it gives near, as well as extensive views of the system. The drawback of our own globe is, that it always keeps at the same distance, or nearly so, from all the bodies of the system, so that, although it is constantly moving onwards, we are kept at such a distance, that we see but little change in the celestial scenery.

It is like an excursion steamer, constantly sailing round, in a narrow circuit, a buoy moored in the middle of a wide lake. The view of the surrounding scenery never changes, and the minute objects of the landscape are never seen. The comet, on the other hand, is like the steamer that sails up the whole length of the lake on one side, and comes down along the other side. Every object is seen minutely, and from different points of view.

Most comets, too, rise above the plane of the solar system, so that we may have a clear view of the relation of one planet to the other. The early misconception as to the arrangement of the solar system arose chiefly from the circumstance that, from the position of the earth, we see it in section, not in plan.

When two armies meet, it is difficult for the one to comprehend the dispositions of the other, and hence the plan, sometimes resorted to, of employing balloons, to enable the one party to look down from above upon the position taken up by the other. The orbit of the comet is, in like manner, usually so situated, that it commands such a view of the solar system; and the sun, and its surrounding planets, are seen as distinctly as the central body of an army, with all its outlying forces, is seen from the balloon.

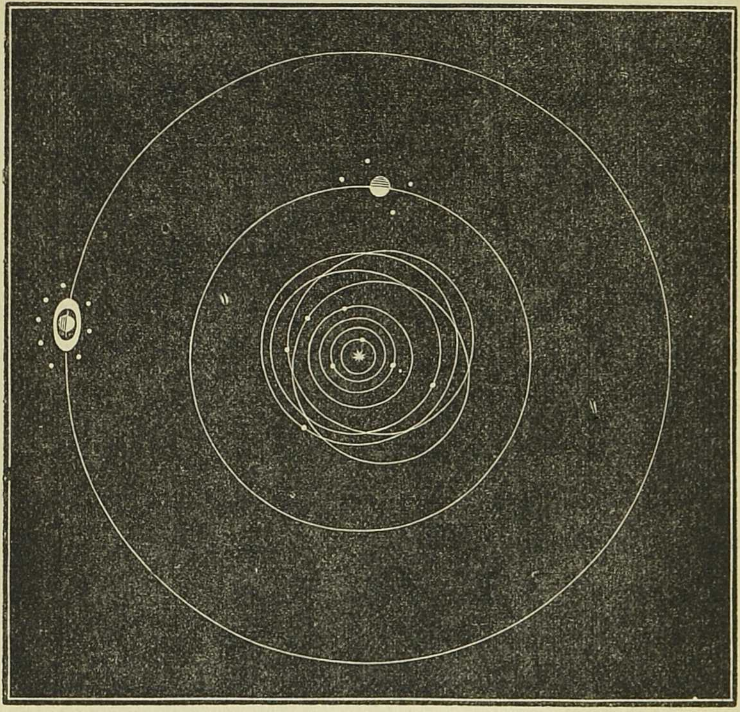
Comets, however, occasionally move on the same level with the planets, and it is from a comet with such an orbit that the best view can be obtained of them individually. The comet may, in this case, come so close that the planetary orbs may be caught in the sweep of its tail. A planet may at one time be seen so large as to cover most of the celestial hemisphere; at another, so minute as to appear but a point of light in the dark concave.

Then, again, let us consider the rate at which the comet travels. This is by no means an equable one. Sometimes it moves so slowly, that a child might keep up with it; at another, it speeds round with lightning velocity.

It is like a coach going down a declivity without a drag. It increases its velocity till it comes to the bottom of the hill, and the momentum acquired carries it up the opposite side, till it gradually slackens and assumes a snail's pace. The comet approaching the sun is going down-hill, and when it reaches the nearest point it wheels round, and then ascends till its speed is gradually arrested. It is reined in by the sun, from which there are invisible lines of forces dragging it back; and, if its momentum be not too great, it is effectually checked and brought back to pursue its former course. Most frequently, however, its course is so impetuous that all the strength of the sun, in reining back, avails nothing. It breaks loose like a fiery steed from its master; speeds off into space, and is heard of no more.

We shall, first, follow the fortunes of one of the more tractable comets, or those that remain permanent members of the solar system, performing their revolutions regularly round the sun. Of these there are six whose orbits are well determined.

Let us enter the cometary vehicle at some point beyond the confines of the solar system; and Halley's comet makes an excursion three hundred millions of miles beyond Neptune—the most distant planet in the



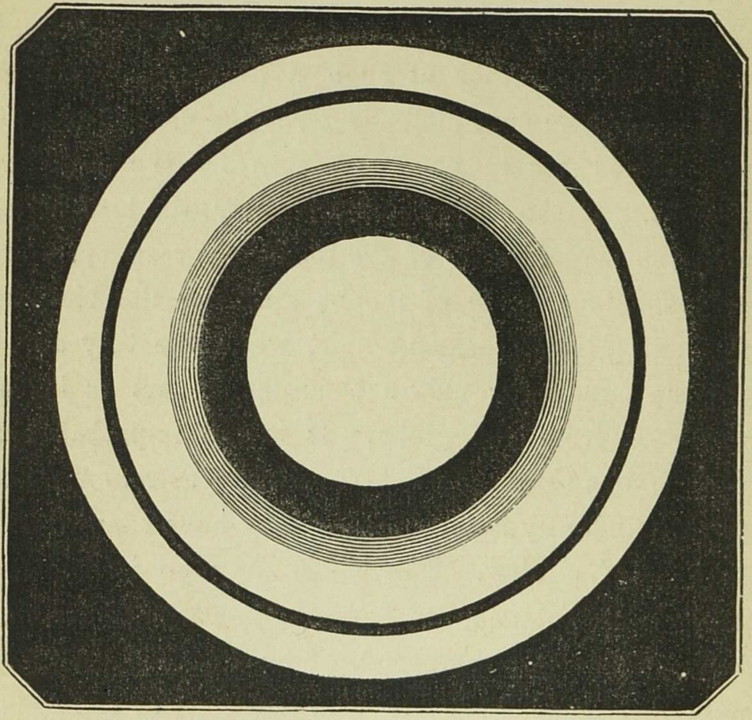
SOLAR SYSTEM.

system. Here the comet is a globular mass, lazily floating along like a filmy cloud in the heavens. It is on its way to the sun, and we shall suppose that the planets are so many stations on the line.

When we near Neptune, his attraction is powerfully felt. The sun would have us go straight on, but our motion is so slow, and the sun so distant, that Neptune readily drags us out of our course.

Here we may discover objects that have escaped the keen eye of astronomers. No astronomer has ever detected more than one satellite; but we may well suppose that this arises, not from their non-existence, but from their invisibility at such a distance. As planets recede from the sun, distance from the centre of light is compensated for in some measure by the number of satellites. If the day wants brilliancy, the loss is made up by the magnificence of the moonlight scenery. There are probably crowds of moons studding the Neptunian skies, and giving cheering light when the tiny sun has set—the sun being only a thousandth part as large as it appears from our globe. It is not improbable that Neptune has rings like Saturn. Some astronomers have pretty confidently asserted that they have sometimes got glimpses of a ring. The rings may be invisible, not merely from distance, but from the dimness of the matter of which they are composed. The dark ring of Saturn would not be seen by the best telescope at the distance of Neptune.

When we alight on the surface of Neptune, we find a little more difficulty in locomotion. A man who weighs twelve stones on the earth, would here weigh sixteen stones; and having this additional weight, with the same muscular strength, difficulty of movement would necessarily be the result. This does not arise from the density of the planet, but from its superior mass. So far from the matter being dense, it is on the whole no heavier than water. This, however, is on the supposition that we see the solid surface of the planet. What we see, however, may be only an envelope far above

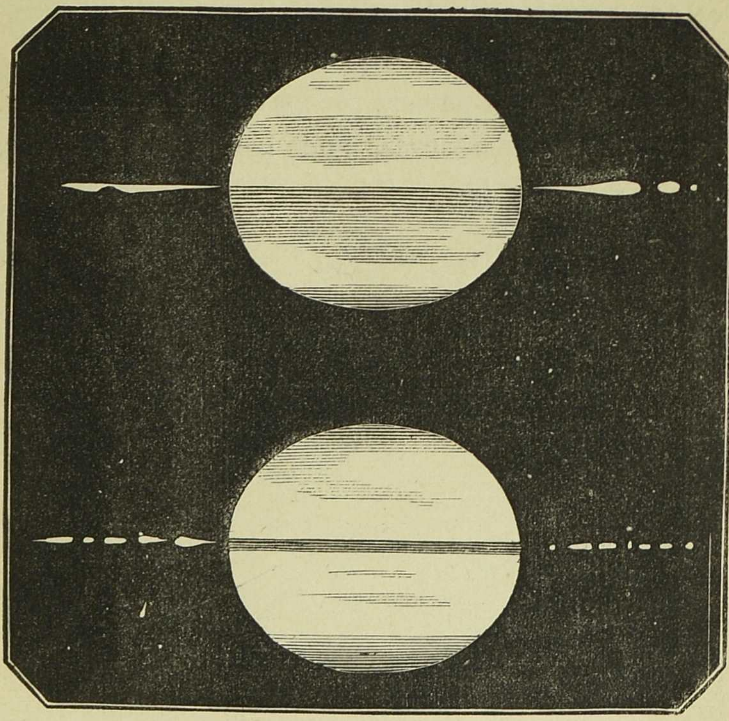


SATURN AND RINGS SEEN FROM ABOVE.

the surface of the nucleus, which may have a much greater density.

Though the sun has dwindled down to one-thousandth its size, its light is by no means so dim as might be supposed. We have a proof of this in the case of eclipses. If the most slender crescent be left uncovered by the moon, the diminution of light is by no means startling. It is only at the moment of totality that the dread effects of an eclipse are produced.

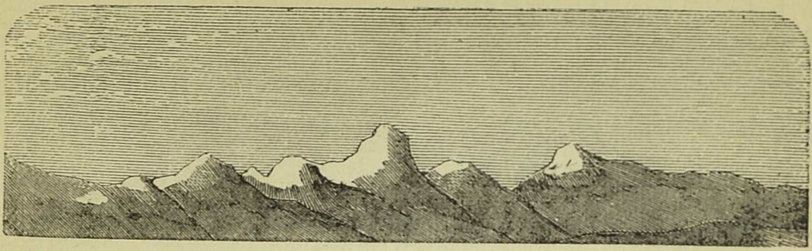
We can well enough conceive of the Neptunians thriving very well, notwithstanding their stinted supply



SATURN AND RINGS SEEN FROM THE SIDE.

of light; and we can suppose that all unpleasant effects might be completely obviated, by having the pupil of the eye enlarged, and the sensibility of the retina increased. The diminution of heat would be more difficult to endure, but, with a properly constituted atmosphere, and with the central heat of the planet itself, we can have no difficulty in conceiving of its being inhabited.

The human frame proves how low a temperature is compatible with the functions of life. In this climate the sinking of the temperature ten degrees below the freezing point, is more keenly felt than a sinking of twenty degrees below zero during a Canadian winter. The reaction of the vital powers seems to come more into play at very low temperatures, and hence the wide range through which life is possible.



A JOURNEY THROUGH SPACE.

CHAPTER II.

IN THE SOLAR SYSTEM.

THE next station is Uranus, but the interval between is vast. The stage from the one orbit to that of the other is about one-third of the whole journey to the sun.

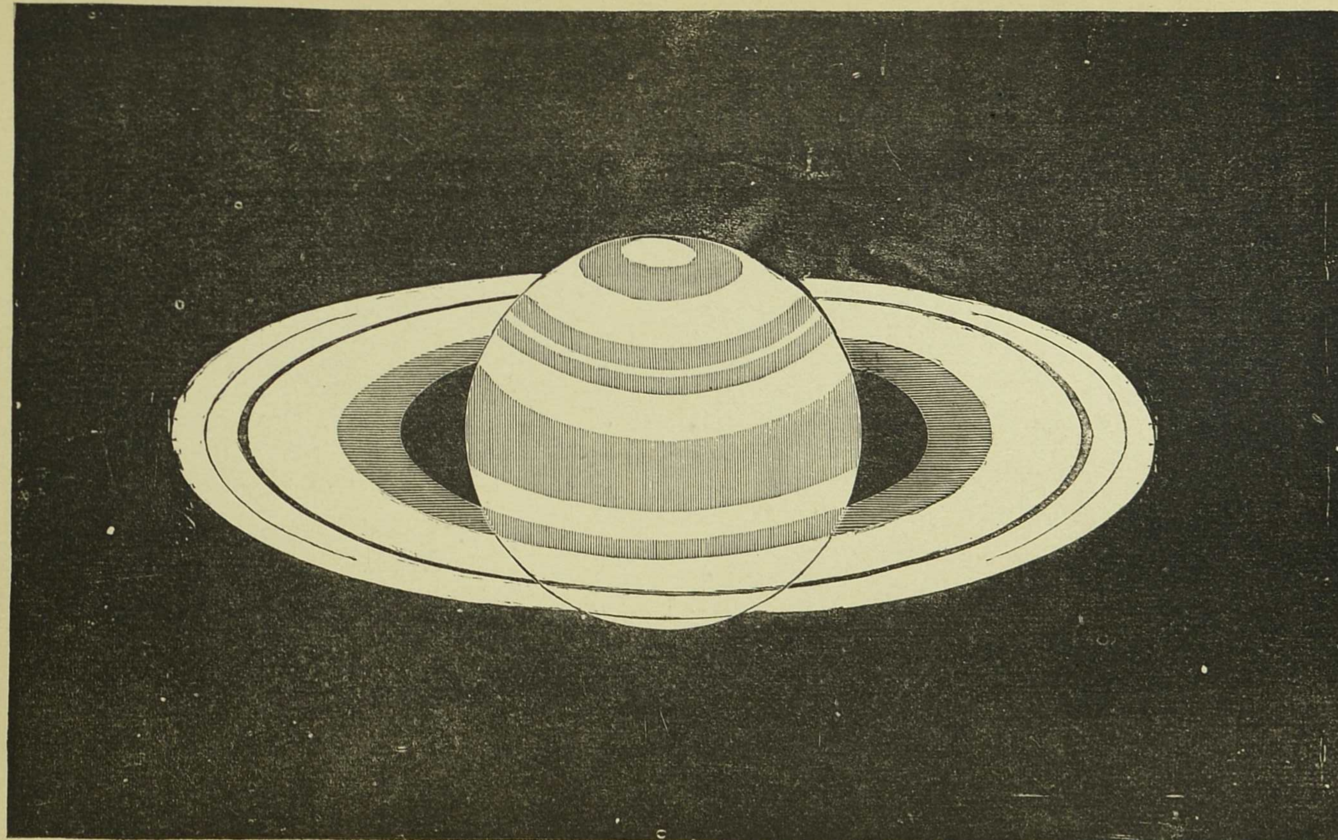
In a railway train, running at the ordinary speed, this distance could not be done under less than six thousand years; so that, if the train started at the creation of man, it would not have yet reached this first station on the way to the sun. The planets, however, are closer as you approach the sun, just as on a railway the stations become more numerous as you approach the metropolis.

In our cometary vehicle, the speed is always increasing, so that, although slow as a railway train at first, it soon acquires immensely greater speed as it rushes on towards its distant goal. The comet of Halley, though starting so far beyond the verge of the system, takes only about forty years to reach the sun. The railway train, going always at the same rate, would take ten thousand years from the outer circle of the system to the centre.

With our increased velocity, Uranus has less influence in drawing us out of our course. Here we find numerous satellites. Sir William Herschel discovered six, but only four have been detected by others. It is, however, highly probable that the number is greater even than that assigned by Herschel. In Uranus we should find ourselves more at home than in any other planet, as far as weight is concerned. Our power of locomotion would be very much the same as here. The most notable fact connected with Uranus is, that his satellites revolve in a direction the opposite to that of all the planets and satellites of the solar system. The nebular hypothesis is very much founded upon the uniformity of the system in this respect, and this breach of uniformity presents a rather baffling discrepancy.

Our next stage is somewhat shorter than the last; still the interval between Uranus and Saturn is immense; but when we reach this station, we have only a third of our journey before us.

Here we are in danger of being completely drawn out of our course, the attraction of the planet being so powerful. Its size is such that it could contain within



SATURN.

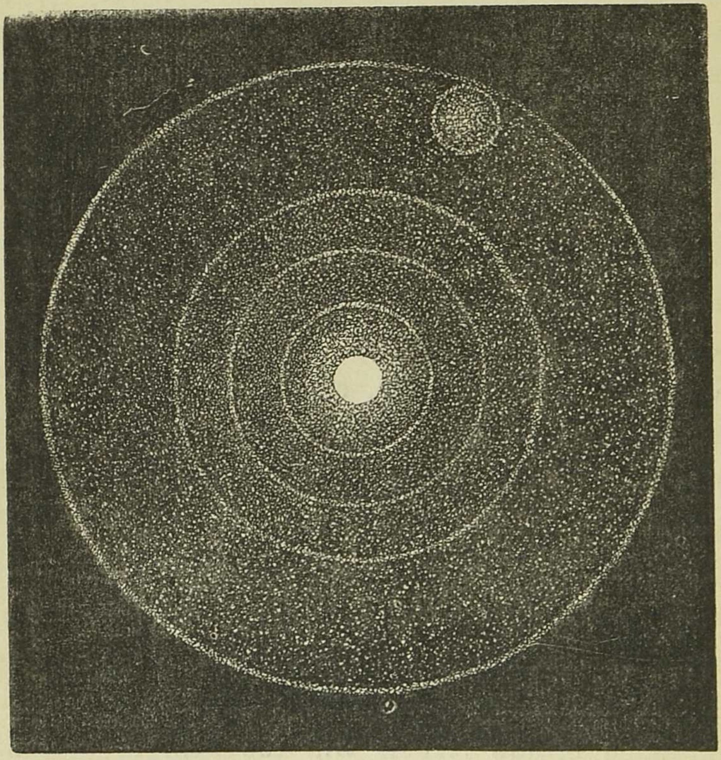
its sphere seven hundred and seventy two terrestrial globes. It is, however, as light as cork; and the consequence is, that standing on its surface, you do not feel yourself dragged down by its attraction; you feel no material difference in this respect between it and our own globe.

An opportunity is now afforded of inspecting the mystery of the rings. You will probably discover many more rings, or rather what appears a single ring will be found to consist of many smaller ones. You can see through the dusky ring, and have an opportunity of detecting its nature. You will find it to be different from vapour or gas, and to consist of aerolites of considerable size, though at the distance of the earth it would appear as if you were looking through a cloud of fine dust. It is probable, also, that you will find the brighter rings to be of a similar nature, though the bodies of which they are composed may be larger and more closely packed together. The rings have, not without reason, been suspected to be rows of satellites so closely moving together that they appear to be one solid body. This accounts for the occasional appearance of divisions, and their subsequent obliteration.

On none of the planets will the heavens present so grand a spectacle. The rings, shining with the lustre of the moon, will constantly arch the heavens. From the effect of perspective, the arch will appear broadest at the summit, and gradually to taper towards the horizon. The eight moons, some of them threading the outline of the ring, will be seen in different phases in the sky; the stars will be seen setting behind the bright bars, and reappearing in the dark spaces between.

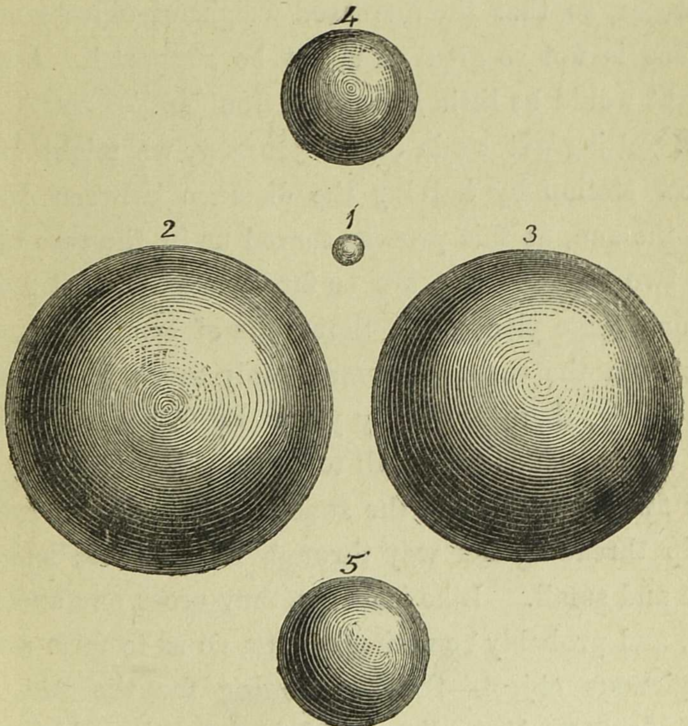
We next reach Jupiter, nearly midway between Saturn and the Sun.

It was here that Lexel's comet got entangled in the



NEBULOUS RINGS.

satellites, and was thrown quite out of its course by the overpowering attraction of the planet. A proof was on this occasion afforded of the almost ethereal constitution of the comet. While the comet was driven about at the mercy of every body it met, it had no power whatever to disturb the course of the smallest bodies it came in contact with, and the mass of the heavenly bodies is determined by this power of disturbing other bodies. In the case of the comets, no disturbing power has been detected, and no mass can be assigned to them.



RELATIVE SIZES OF PLANETS.

1. Earth. 2. Jupiter. 3. Saturn. 4. Uranus. 5. Neptune.

How stupendous an object must Jupiter have appeared to an eye in Lexel's comet, when it swept through its satellites! The disk must have covered a great part of the heavens as a brilliant canopy, and the rotation would be distinctly sensible, as some marked cloud would be seen appearing at one edge of the disk, and, in five hours, disappearing at the other. Jupiter is by far the largest planet in the system. His dimensions are such, that it would take fourteen hundred and ninety-one terrestrial globes to equal him. The density, however, is only that of water, so that the increased weight of objects on his surface is not so great as might be supposed. A man's weight would be little more than doubled.

In setting out again on our journey, we might expect a new station by halving the distance between Jupiter and the sun, as this process served us in the case of our last two stages. We are so far successful, that we find not one large planet, but thousands of small ones. We have from the earth discovered only seventy, but, in all probability, there are many yet to be discovered : there may be thousands too small to be detected.

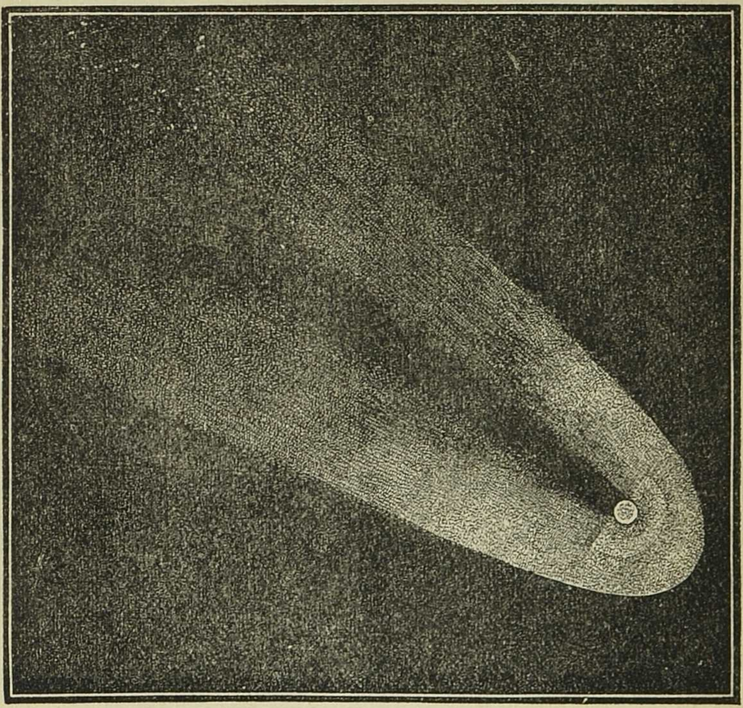
In sweeping through the zone of asteroids, we are like a ship threading her way through innumerable icebergs, large and small. Like icebergs, they cross one another's path, and probably sometimes unite, so as to form a more conspicuous object—thus accounting for the fact, that asteroids have been discovered in localities which were scrutinized with the utmost care a little before, and were found not to exist. It is easy to understand how two bodies, invisible from their smallness, should become a notable object when united.

Well, let us now step on one of these miniature worlds, no larger than an English county. With our present muscular strength, we could easily clear the broadest rivers and the loftiest spires—our bodies being literally lighter than a feather. We could readily keep up with the rotation of the asteroid, and prevent the sun from setting. We could have all climates at command. We could withdraw to the polar regions during the heat of the day, and return to the torrid zone to spend the evening. Cyclopean structures might be raised compared with which the pyramids of Egypt would be but molehills. The very globe itself might be tunnelled and split up, so that contending parties might have little worlds of their own to live in.

The imagination can thus easily revel in the wildest fancies, if we exchange the normal conditions of life for extreme physical suppositions. This zone of asteroids serves as the boundary between the two distinct groups of planets. The planets which we have already visited have all distinctive characters, and a family likeness. They are characterized by their greater size and their remarkable lightness. The outer planets may be compared to wood, while those within the zone of asteroids are more allied to metals in density.

But our fiery chariot is now, on account of its proximity to the sun, experiencing strange internal changes. The globular mass is now elongated towards the sun, the nucleus being situated near the foremost end, and as we approach still nearer, the nucleus is thrown into a state of wild excitement. A jet of bright luminous matter rises from it, similar in shape to a bat-wing gas-burner; and, in other respects, this fan of light is not unlike a jet of gas. It is sometimes seen to dance like a gas-burner when there is water in the pipe. The whole comet seems for a moment or two to be extinguished, and then suddenly flashes out with its former brilliancy.

This excited action increases in intensity, till the comet reaches its nearest point to the sun, and it is only



HEAD OF DONATI'S COMET.

after the comet has emerged from the rays of the sun, that it has attained its maximum brilliancy. The motion of the comet, and the increase of brilliancy, are sometimes so rapid, that it appears to burst all at once, as in the case of the recent comet, upon an astonished world.

As our vehicle now advances with such rapidity, and

THE EARTH IN SPACE.

as the stations are now very close to one another, we shall take but a cursory glance at each body as we advance.

The first of the heavy planets is Mars, and on his surface we can readily descry the circle of snow at the poles, and the general outlines of his continents.

The Earth next appears with her surrounding blue tmosphere. Her continents and oceans are seen dimly down through the openings in the clouds that float in her atmosphere. Belts more or less distinct, corresponding to the trade-winds, will also be detected.

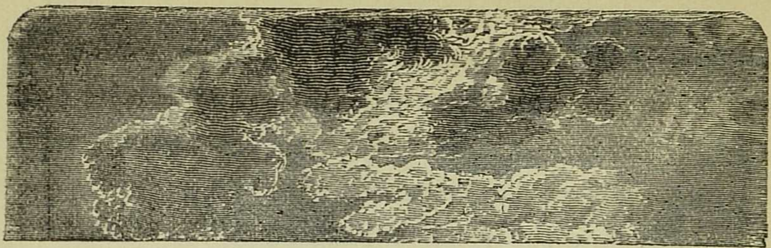
We pass, in rapid succession, Venus, Mercury, and Vulcan; and we probably find that Vulcan is only one of innumerable asteroids that form a zone between Mercury and the sun. At last we reach the goal, and find ourselves in close proximity to the Sun.

Conceive of our sun expanding, so as to fill the whole concave of the sky, and we shall have some conception of a comet's approach to him; and, in their daring course, comets sometimes almost graze his surface.

Here the diamond would flash into flame like gunpowder, and the hardest metal would, in an instant, be volatilised, so intense must be the heat. Here, too, we may closely survey those mysterious, rose-coloured flames, seen in total eclipses, that have so puzzled observers.

Through the luminous envelope we see down into these perforations, which appear as dark spots from the earth. These minute specks are now seen to be gulfs down which the earth could be projected with the greatest ease; and so capacious is the sun, that he could engulf all the planets of the system, and yet show no appreciable difference in size. Millions of aerolites and comets have probably been engulfed already, and yet millions more would not visibly enlarge the furnace.

To understand the relative position of the stations at which we have stopped in our excursion, it is necessary to assign a scale. If, then, we call the distance of the earth to the sun one mile, the distance of Neptune will be thirty miles ; and our nearest neighbour, the moon, will only be four yards from us. To expand this scale to represent the reality, we have only to keep in mind that a railway train, going at the rate of thirty miles an hour, and travelling day and night, would take twenty thousand years to go straight across the whole breadth of the solar system.



A JOURNEY THROUGH SPACE.

CHAPTER III.

IN THE BOUNDLESS.

WE have now passed through the vast system which revolves around the sun.

But, after all, this journey is nothing more than a morning drive to the houses of a few friends in the neighbouring streets. We have still an expedition before us, which may be compared to the crossing of the Atlantic, or a voyage to China. We have not yet really left home, and now that we propose going abroad, what vehicle shall we take to aid us in our flight to other systems? The comet is all too slow for our purpose. We must have something still more subtle and swift. The only physical agency that can serve our purpose is a ray of light.

On a ray of light we may reach the moon in a single second, and the sun in eight minutes. Instead of taking twenty thousand years, like the railway train, to cross the solar system, it would require only eight hours.

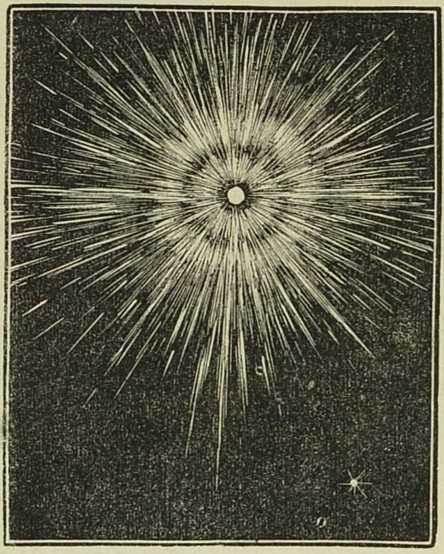
Let us suppose, then, that, with the ethereal vehicle of light, we are to start upon a journey far beyond the solar system, where shall be our first resting-place? Alpha centauri is the nearest of the stars whose distance has been well determined; but with all the spiritual swiftness of light, we can reach it only in three years and a quarter.

We are separated from the planets by an interval that may be compared to the breadth of a river; but an expanse like the Atlantic ocean separates us from the nearest of the fixed stars.

The smallest stars visible to the naked eye can probably be reached by a ray of light only in about fourteen years; and the smallest stars visible in the largest reflectors would probably require a journey of four thousand years.

Let us now start from the star on which we have gained a footing, for a position from which we may look down upon the group of fixed stars to which our sun belongs. Having gained this position, we find that the sun is part of the Milky Way, which lies like a bright ring before us, with perhaps a tendency to the spiral structure; the cleft in the galaxy corresponding to a coil of the spiral. To expand this ring to its true dimensions, we must remember that a ray of light would probably take a thousand years to speed across its whole breadth.

From this position we find that the milky way, with its millions of stars, is not the only luminous disk. The whole heavens are studded over with similar patches of light, which, on closer inspection, are found to be firmaments, consisting, like the milky way, of innumerable stars. They may appear as single, hazy stars, but they are the combined light of countless hosts. These groups

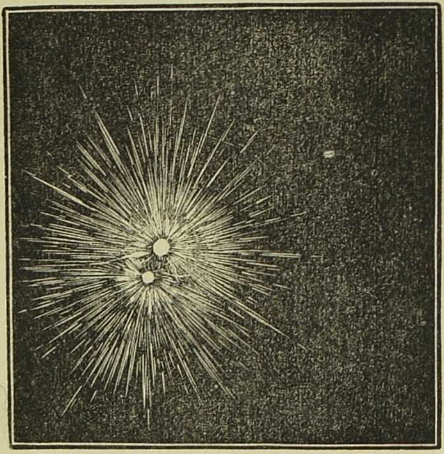


STAR WITH AURORA.

are separated by gulfs which it would require millions of years for a ray of light to traverse.

From the simple law that light requires time to travel from one point to another, it follows that we see everything in the past. In the case of very distant objects, this leads to startling results. For every event in the past history of the world, there is a corresponding point in space, and if we were situated on a star at that point, we should, on looking down upon the earth, see the corresponding event transacted.

For example, if we took up our position in a star, to which light would take six thousand years to travel from this globe, we should witness the scenes of paradise, and the *rôle* of the world's history would unfold itself to our eyes. If the course of events appeared too slow, we



DOUBLE STAR.

could hasten it, in any degree, by gliding swiftly towards the earth, along the course of the rays. If we could accomplish the journey in an hour, the history of six thousand years would be condensed into that period.

The schoolmen defined eternity as *punctum stans*, and the propagation of light gives a startling illustration of their meaning. We can arrest the flow of time by continued motion.

Suppose our world is the illuminated dial of a clock, that the hand is at twelve o'clock, and that the machinery is faithfully doing its duty; we have only to take up our position in a star that moves from the earth as rapidly as the rays from the dial, in order to arrest the hand for

PART OF MILKY WAY.

ever at that hour. To one who is stationary, the hand makes its ordinary revolution; but one who moves away with the rapidity of light sees it perfectly fixed.

Nay, it is possible to turn back the hand of the dial. In a star moving away from the earth more rapidly han the light, a person would see the hands gradually move in the reverse order from twelve to eleven o'clock, and so on. By moving in the direction opposite to that of the light, centuries might be concentrated into hours, and hours into seconds.

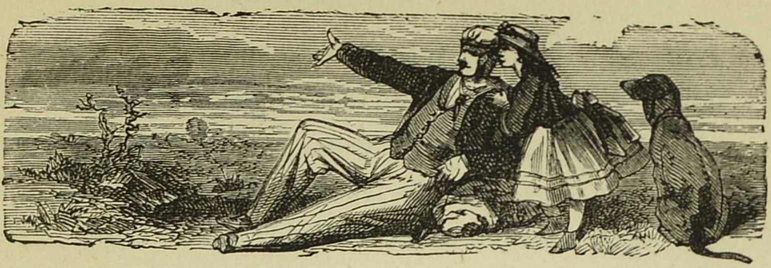
PLEIADES.

Had we unlimited powers of locomotion, we should not be under the necessity of reading unintelligible and prosaic accounts of campaigns and battles in the past history of our country; it would only be necessary to wing our way to some star where the light from the seat of war is just arriving, and leisurely watch the actual progress of the campaign or battle.

These curious relations of space and time, as linked together by the laws of light, sufficiently show how the properties of matter may aid the spirit, in a future state of being, in obtaining a wide and comprehensive view of the works and the providence of God. Matter and force, as far as we know, are indestructible, and time itself, the most perishable, in one sense, of all things, is, in another, indestructible too. It can be recalled, as we have seen, and forced again to do duty, by repeating the events of the past.

When we step from planet to sun, from sun to system, and from system to firmament, we are ascending the rounds of the ladder that leads up to the Infinite; and this is the great end of the book of God in the Heavens.

THE SUN.



THE SUN.

CHAPTER I.

HIS DISTANCE FROM THE EARTH.

THE distance of the sun from the earth is inconceivable. Figures will speak it, but the mind cannot realise it.

Yet to attain any idea of the amazing power which the sun exerts, we must consider its distance from the objects of its silent, mighty care.

The first and most important office the sun has to perform is to keep our system together, to keep its members from running off out of the reach of his genial beams into outer darkness.

Were the sun simply *extinguished*, the planets would all continue to circulate round it as they do at present, only in cold and darkness; but were it altogether destroyed, annihilated, each would from that moment set forth on a journey into infinite space in the direction in which it happened then to be moving. It would wander on, centuries after centuries, lost in that awful abyss which separates us from the stars. Yet so vast is that space, that it would wander on without making any sensible approach even to the nearest of them for hundreds or even thousands of years.

The power by which the sun is enabled to perform this office—to gather the planets round its hearth and to keep them there—is the same in kind (though very different in intensity) as that which when a stone is thrown up into the air, draws it down again to the earth.

In order to understand how it is possible to pass from this familiar case that we see every day before our eyes, to that of a vast globe like the earth revolving in an orbit about the sun, it will be necessary to enlarge the scale of our ideas of magnitude. We must try to conceive a similar degree of command and control exercised over such a mass as our globe, and over the much greater masses of the remote planets, by the sun as a central body; hardly moved from its place, while, as it were, swinging all the others round it.

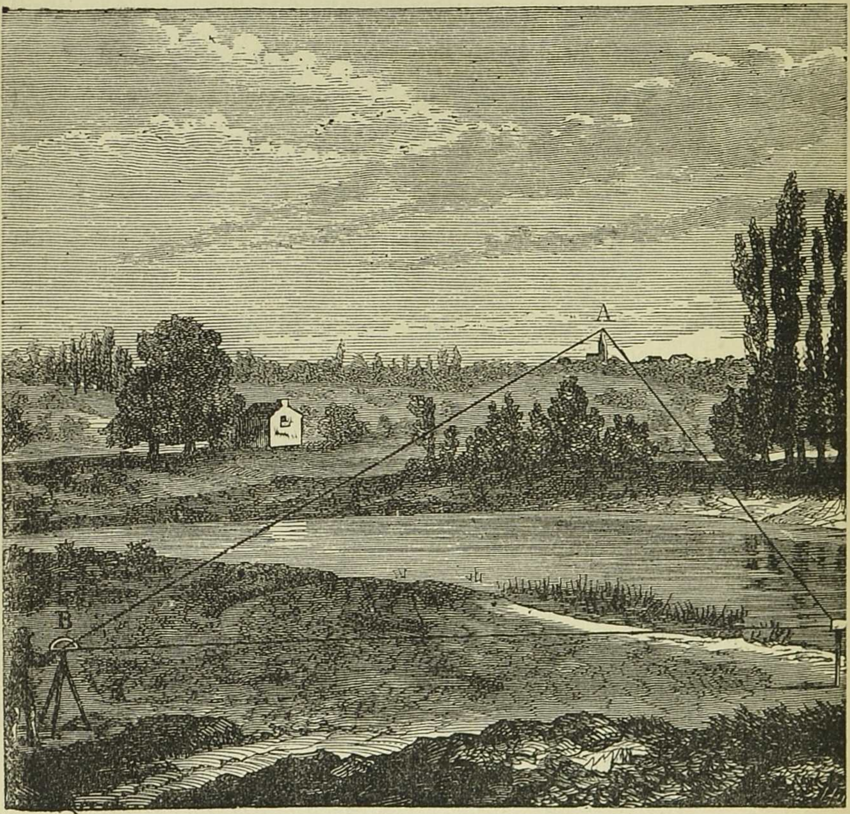
For this purpose it is necessary to possess some distinct conception of the sun's distance from us.

Now, the simplest way to find the distance of an object which cannot be got at, is to measure what is called a base line from the two ends of which it can be seen at one and the same moment, and then to measure with proper instruments the angles at the base of the triangle formed by the distant object and the two ends of the base.

Geography and surveying in modern times have arrived at such perfection, that we know the size and form of the earth we stand upon to an extreme nicety. It is a globe a little flattened in the direction of the poles, —the longer diameter, that across the equator, being 7,925 miles and five furlongs, and the shorter, or polar axis, 7,899 miles and one furlong; and in these measures it is pretty certain that there is not an error of a quarter of a mile. And knowing this, it is possible to calculate with quite as much exactness as if it could be measured, the distance *in a straight line* between any two places whose geographical positions on the earth's surface are known.

Now there are two astronomical observatories very remote from one another; the one in the northern hemisphere, the other in the southern—viz., at Hammerfest in Norway, and at the Cape of Good Hope, both very nearly on the same meridian, so that the sun, or the moon, or any other heavenly body, attains its greatest altitude above the horizon of each (or, as astronomers express it, passes the meridian of each) very nearly at the same time.

Supposing, then, that its height at noon is carefully observed at each of these two stations, and on the same day, it is easy to find the angles included between each of the two lines. Taking then the line between the two points on which the observers stand for the base of a triangle, those two sides can thence be calculated by



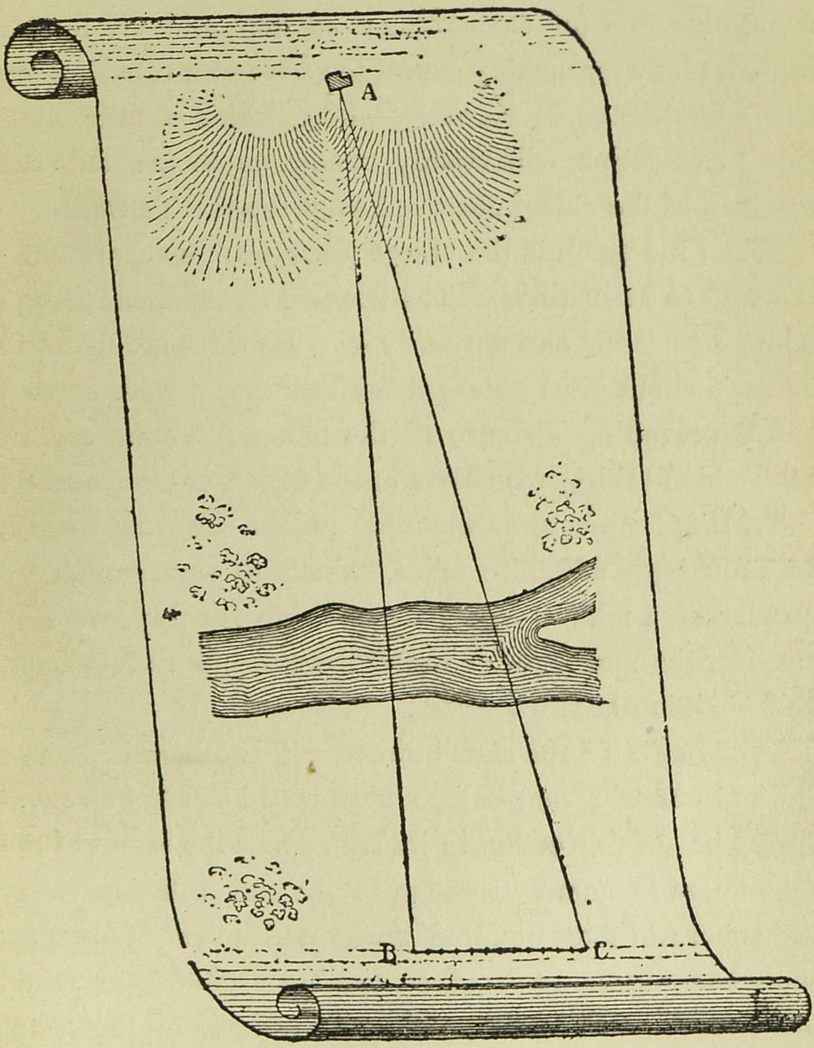
MEASURING A DISTANT OBJECT.

A, B, C triangle; A, distant object, church tower; B, measurer, measuring the angle; C, extent of base line.

the very same process as that employed in geographical surveying.

Suppose, for the sake of aiding the imagination, that

B in the diagram is Hammerfest, that C is the Cape, and that A represents the sun.



MEASURING A DISTANT OBJECT.

Now, the distance between Hammerfest and the Cape in a straight line is nearly 6,300 miles, and owing to the situations of the two places in latitude, the triangle in question is always what a land surveyor would call a favourable one for calculation: so that, with so long a base, we may reasonably expect to arrive at a considerably exact knowledge of its sides,—after which a little additional calculation will readily enable us to conclude the distance of the object observed from the earth's centre.

When the moon is the object observed, this expectation is found to be justified. The triangle in question, though a long one, is not extravagantly so. Its sides are found to be each about thirty-eight times the length of the base, and the resulting distance of the moon from the earth's centre about thirty diameters of the latter, or more exactly sixty times and a quarter its radius—that is to say, 238,100 (say 240,000) miles, which is rather under a quarter of a million—so that, speaking roughly, we may consider the moon's orbit round the earth as a circle about half a million of miles across.

In the case of the sun, however, it is otherwise. The sides of our triangle *are* here what may be called extravagantly out of proportion to its base; and the result of the calculation is found to assign to the sun a distance very little short of four hundred times that already found for the moon—being in effect no less than 23,984 (in round numbers 24,000) radii, or 12,000 diameters of the earth, or in miles 94,880,700 or about 95,000,000.*

* These numbers and all the subsequent statements in miles are too large by about one mile in thirty-one.

When so vast a disproportion exists between the distance of an object and the base employed to measure it, a very trifling error in the measured angles produces a great one in the result. Happily, however, there exists another and a very much more precise method, though far more refined in principle, by which this most important element can be determined; viz., by observations of the planet Venus, at the time of its "transit" (or visible passage) across the sun's disc.

The real diameter of the sun has been calculated at 882,000 miles, which I suppose may be taken as exact to a few odd thousands.

Now, only let us pause a little, and consider among what sort of magnitudes we are landed. It runs glibly over the tongue to talk of a distance of 95,000,000 of miles, and a globe of 880,000 miles in diameter, but such numbers hardly convey any distinct notion to the mind. Let us see what kind of conception we can get of them in other ways.

And first, then, as to the distance.

By railway, at an average rate of forty miles an hour one might travel round the world in twenty-six days and nights. At the same rate it would take two hundred and seventy years and more to get to the sun.

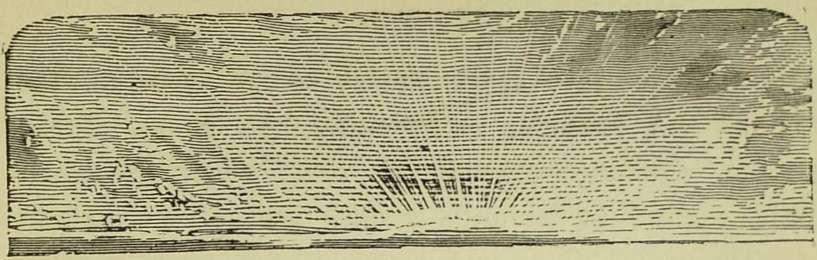
The ball of an Armstrong hundred-pounder leaves the gun with a speed of about four hundred yards per second. Well, at the same rate of transit it would be more than thirteen years and a quarter in its journey to reach the sun; and the sound of the explosion (supposing it conveyed through the interval with the same speed that sound travels in our air), would not arrive till half a year later.

The velocity of sound, or of any other impulse conveyed along a steel bar, is about sixteen times greater than in air. Now, suppose the sun and the earth connected by a steel bar. A blow struck at one end of the bar, or a pull applied to it, would not be delivered —would not begin to be felt—at the sun till after a lapse of three hundred and thirteen days.

Even light, the speed of which is such that it would travel round the globe in less time than any bird takes to make a single stroke of his wing, requires seven minutes and a half to reach us from the sun.

By supposing the sun connected with the earth by a steel bar, some notion may be obtained of the wonderful connection which that mystery of mysteries, gravitation, establishes between them.

The sun *draws* or pulls the earth towards it. We know of no material way of communicating a pull to a distant object more immediate, more intimate, than grappling it with bonds of steel; and how such a bond would suffice we have just seen. But the *pull* on the earth which the sun makes is instantaneous, or at all events incomparably more rapid in its transmission across the interval than any solid connection would produce, and even demonstrably far more rapid than the propagation of light itself.



THE SUN.

CHAPTER II.

HIS MAGNITUDE.

LET me now try to convey some sort of notion of the *size* of the sun.

On a circle six feet in diameter, representing a section of it through the centre, a similar section of the earth would be about represented by a fourpenny-piece, and a distance of a thousand miles by a line of less than one-twelfth of an inch in length. A circle concentric with it, representing on the same scale the size of the moon's orbit about the earth, would have for its diameter only thirty-nine inches and a quarter, or very little more than half the sun's.

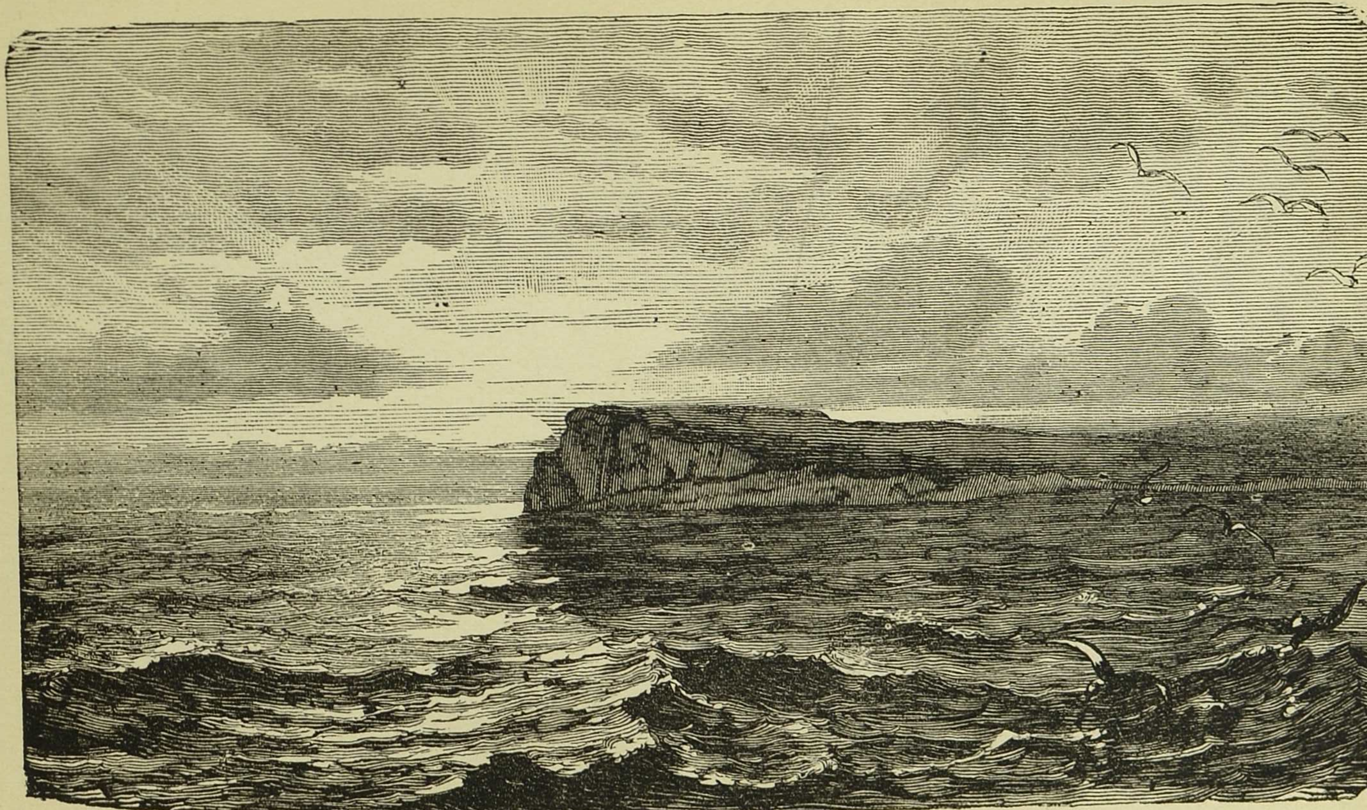
Imagine now, if you can, a globe concentric with this earth on which we stand; large enough not only to fill the whole orbit of the moon, but to project beyond it on all sides into space almost as far again on the outside! A spangle, representing the moon, placed on the circumference of its orbit so represented, would require to be only a sixth part of an inch in diameter.

It is nothing to have the size of a giant without the strength of one.

The sun retains the planets in their several orbits by a powerful mechanical force, precisely as the hand of a slinger retains the stone which he whirls round till the proper moment comes for letting it go. The stone pulls at the string one way, the controlling hand at the centre of its circle the other. Were the string too weak, it would break, and the stone, prematurely released, would fly off in a tangential direction.

If a mechanist were told the weight of the stone (say a pound), the length of the string (say a yard, including the motion of the hand), and the number of turns made by the stone in a certain time (say sixty in a minute, or one in a second), he would be able to tell precisely what ought to be the strength of the string so as *just not to break;* that is to say, what weight it ought at least to be able to lift without breaking.

In the case I have mentioned, it ought to be capable of sustaining 3 lbs. 10 ozs. 386 grs. If it be weaker it will break. And this is the force or effort which the hand must steadily exert, to draw the stone in towards itself, out of the direction in which it would naturally



SUNRISE.

proceed if let go; and to keep it revolving in a circle at that distance.

Now, what the string does to the stone in the sling, that, in the case of the sun retaining the earth in its orbit, is done—that same office is performed—that *effort* (in some mysterious way which the human mind is utterly incapable of comprehending) is exerted—that pull communicated; in an instant of time, and so far as we can discover, without any material tie; by the force of gravitation.

We know the time the earth takes to revolve about the sun. It is a year; of so many days, hours, minutes, and seconds; and we know its distance—95,000,000 of miles, which may easily be turned into yards. Well, now, suppose a stone or a lump of lead of a ton weight to be tied to the sun by a string, and slung round it in such a circle and in such a time. Then, on the very same principles, and by the same rules of arithmetic, one may calculate the amount of pull, or tension of the string, and it will be found to come out 1 lb. 6 ozs. 51 grs.

We all know what sort of lifting power—what amount of muscular force—it takes to sustain a pound weight. Multiply this by 2,240, and you have the muscular effort necessary to sustain a ton. It would require three or four strong horses straining with all their might. Well, now, it is one of the peculiarities of this mysterious power of gravitation, that its intensity—the energy of its pull—is less and less as the distance of the thing pulled is greater: and *that* in a higher proportion. At double the distance, the force of the pull is not halved, but quartered: at triple, it is not a third part, but a ninth.

There are mountains in the world five miles high; that is to say, whose summits are five miles farther from the centre of the earth than the sea-level. If a ton of lead were carried up to the top of such a mountain, though it would still balance another ton, or 2,240 weights of a pound each on the scales, then and there, yet it would not require so great an effort, such an exertion of muscular force to raise and sustain it by five pounds and a half. Now, fancy it removed to a height of 94,900,000 miles from the earth's surface, and estimating by the same rule its apparent weight, you will find, if you make the calculation, that it would not require more effort to sustain it from falling, than would suffice to lift one-thirty-seventh part of a grain from the surface of the earth.

This, then, one-thirty-seventh part of a grain, is the force which the earth, placed where the sun is, would exert on our lump of lead. But we have seen that to retain such a lump in such an orbit requires a pull of 1 lb. 6 ozs. 51 grs. Of course, then, the earth so placed would be quite inadequate to retain it from flying off. To do this would require as many earths to pull it as there are thirty-seventh parts of a grain in 1 lb. 6 ozs. 51 grs; that is to say, by an easy sum in arithmetic, 356,929, or in round numbers 360,000. Now, this is equivalent to saying, that to do the work which the sun does upon each individual ton of matter which the earth consists of, it must pull it as if (mind I say *as if*) it were made up of 360,000 earths. And this is what is meant by saying, that the mass of quantity of gravitating matter constituting the sun is 360,000 times as great as the mass or quantity of such matter in the earth.

Thus, now, you see, we have weighed as well as measured the sun, and the comparison of the two results leads to a very remarkable conclusion.

In point of size, the globe of the sun, being *in diameter* 110 times that of the earth, occupies *in bulk* the cube of that number, or 1,331,000 times the amount of space. The disproportion in bulk then is much greater than the disproportion in weight—very nearly four times greater; so that you see, comparatively speaking, and of course on an average of its whole mass, the sun consists of *much lighter* materials than the earth.

From this calculation of the mass of the sun, and from its diameter, we are enabled to calculate the pressure which any heavy body placed on its surface would exercise upon it, or, in other words, what power it would require to lift it off. It is very nearly thirty times the power required to lift the same mass here on earth.

A pound of lead, for instance, transported to the sun's surface, could not be raised from it by an effort short of what would lift thirty pounds here. A man could no more stand upright there, than he could here on earth with twenty-nine men on his shoulders. Indeed, he would be squeezed as flat as a pancake by his own weight.

Giant size and giant strength are ugly qualities without beneficence. But the sun is the almoner of the Almighty, the delegated dispenser to us of light and warmth, as well as the centre of attraction; and as such, the immediate source of all our comforts, and indeed of the very possibility of our existence on earth.

But how shall I attempt to convey to you any conception of the scale on which the great work of warming and lighting is carried on in the sun? It is not by large words that it can be done. All "word painting" must break down, and it is only by bringing before you the consideration of great facts in the simplest language, that there is any chance of doing it. In the very outset here is the greatest fact of all—the enormous waste, or what appears to us to be waste—the excessive, exorbitant prodigality of diffusion of the sun's light and heat. Take all the planets together, great and small; the light and heat they receive is only one 227-millionth part of the whole quantity thrown out by the sun. All the rest escapes into free space, and is lost among the stars; or does there some other work that we know nothing about.

Of the small fraction thus utilised in our system, the earth takes for its share only one-tenth part, or less than one 2,000-millionth part of the whole supply.

SIR JOHN HERSCHEL.

Now, then, bearing in mind this huge preliminary fact to start with, let us see what amount of *heat* the earth *does* receive from the sun.

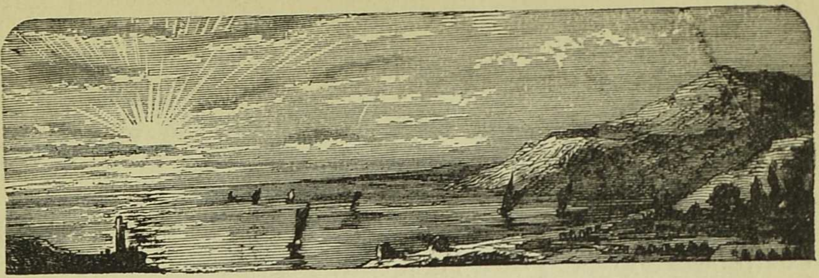
The earth is a globe, and therefore, taken on an average, it is constantly receiving as much, both of light and heat, as a flat circle 8,000 miles in diameter, held perpendicularly to receive it. Now, that section is 50,000,000 square miles, so that there falls at every instant on the whole earth 50,000,000 times as much heat as falls on a square mile of the hottest desert under the equator at noonday with a vertical sun and with not a cloud in the sky—and in fact nearly a third more; for more than a quarter of the sun's heat is absorbed in the air in the clearest weather, and never reaches the ground.

Now, we all know that in those countries it is much hotter than we like to keep our rooms by fires. I have seen the thermometer four inches deep in the sand in South Africa rise to 159° Fahrenheit; and I have cooked a beef-steak and boiled eggs hard by simple exposure to the sun in a box covered with a pane of window glass, and placed in another box so covered.

And now let us endeavour to form some kind of estimate of the *temperature*—that is to say, the degree or intensity of the heat at the actual surface of the sun.

By a calculation, with which I will not trouble you, it turns out to be more than 90,000 times greater than the intensity of sunshine here on our globe at noon and under the equator—a far greater heat than can be produced in the focus of any burning-glass; though some have been made powerful enough to melt, not only silver and gold, but even platina, and, indeed, all metals which resist the greatest heats that can be raised in furnaces.

Perhaps the best way to convey some sort of conception of it, will be to state the result of certain experiments and calculations recently published, which is this—that the heat thrown out FROM EVERY SQUARE YARD of the sun's surface is equal to that which would be produced by burning on that square yard six tons of coal per hour, and keeping up constantly to that rate of consumption—which, if used to the greatest advantage, would keep a 63,000 horse steam-engine at work. And this, mind, on each individual square yard of that enormous surface, which is 12,000 times that of the whole surface of the earth!



THE SUN.

CHAPTER III.

HIS WORK.

JOHN KITTO, before leaving for Cannstadt, there to lay his ashes in its quiet churchyard, was persuaded to have his likeness taken by the photographic process. Notwithstanding the sadness that weighed on his heart, he could not restrain the humour which so often served to buoy up his sinking spirits. He remarked to his daughter, while the photographer was adjusting the apparatus, that "the sun had hitherto lived like a gentleman, but that now he was obliged to work for his living."

But he was mistaken in thinking that the sun had ever the life of a gentleman. He has always worked as a slave, nay, he has been always the slave of slaves. He has really done all the work, while men and their machines have taken all the credit to themselves. They have only directed the work, while all the power has been supplied by the sun.

We speak of the marvellous power of the steam engine; but to what does it owe its power?

The answer is, the elasticity of steam.

But how is this elasticity accounted for?

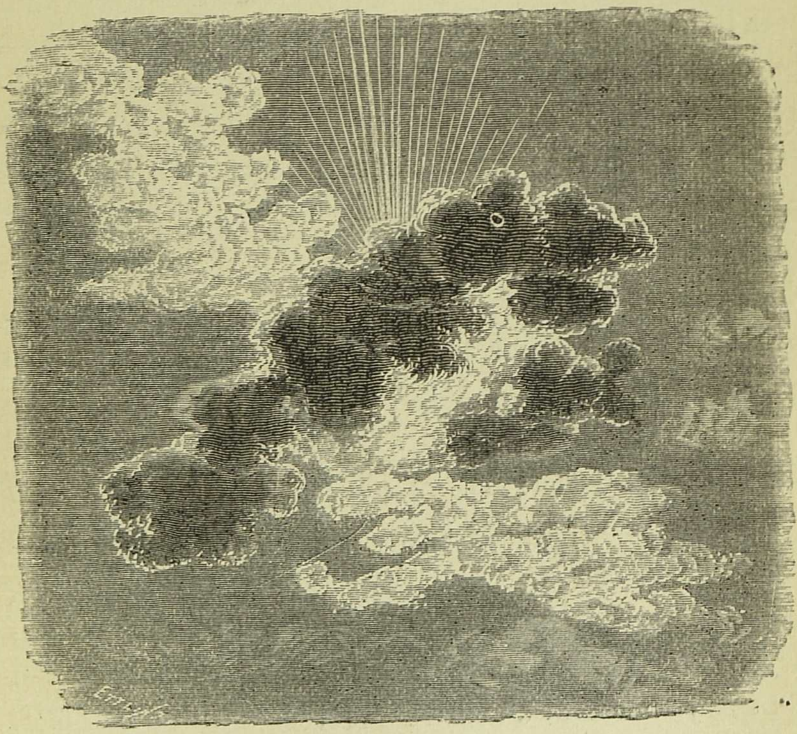
The answer is equally ready, that the heat of the furnace has produced it. But the circle of causation is not yet complete.

From what source has the coal derived its heat?

Till lately the answer would have been satisfactory, that the coal is fossil wood, and therefore it produces heat by burning. But we must now wring from nature the secret of this possession of heat and power by coal. The answer of science is, that the coal is merely a receptacle for the heat and light of the sun. The sun's energy is bottled up, as it were, in the coal, and the burning of it is the uncorking of the bottle.

It may be said that this is only a play upon words, as it is a mere truism to hold that a tree could not grow without the influence of the sun, and that there could be no coals without trees; but that this does not imply that the heat of the coal is the very heat of the sun.

Now, what we wish to impress is, that the identity is complete, and this results from the grand generalisation of recent times, that force, and heat is but a form of force, is indestructible, just as matter is indestructible. God has created a certain amount of force, as well as of matter, in the universe, and it is inconceivable that either should ever be lessened in amount, except by a miraculous act of annihilation. This generalisation now looks like a truism; but how strange is it, that the human mind should arrive at it only in very recent



CLOUD-WATER.

times! But so it is in the whole history of human thought. The inscrutable mystery of one period is the self-evident axiom of another.

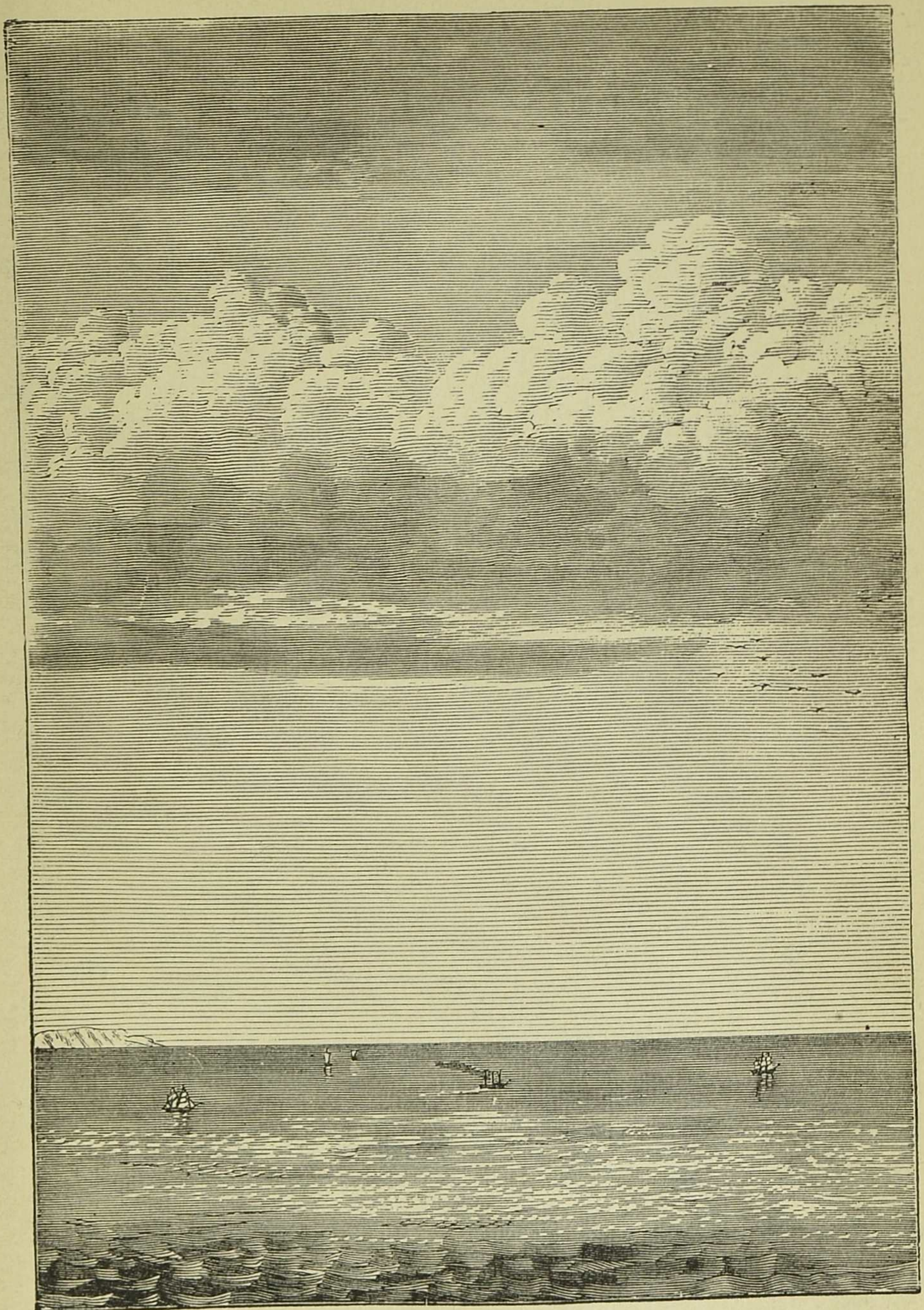
Another source of power of which we avail ourselves is the fall of water. We plant our mills on the banks of a stream, and the descent of the water turns the wheel. We do not readily think of the impalpable rays of the sun turning the spokes of the wheel; and yet the connection is easily traced. The rays elevate the water in the form of vapour from one level to a higher; the vapour is deposited in the form of rain; the rain accumulates in the river; the river fills the bucket of the wheel, and through the operation of the wheel, the heat of the sun is converted into useful, industrial work; and this is done as really as if the rays turned round directly the spokes of the wheel.

It may be said that there is one kind of power at least which cannot possibly be traced to the sun—viz., animal power. The horse in harness, or the labourer with his spade, surely exercises a power that has no relation to the sun? Is not volition a power altogether distinct from material force? Does not the will create force? Science, however, clearly shows that this is no exception to the general rule.

The body is to man what the coals are to the steam-engine. The mind may direct, but it cannot create. And every time that a man strikes a blow with a hammer, he as surely wastes a certain amount of physical force stored up in his body as every stroke of the piston in a steam-engine wastes a certain amount of coals in the furnace. The waste of tissues in the body corresponds to the combustion of coals in the furnace.

But whence the power stored up in these tissues?

The answer is, from the sun. All animal structures



THE TWO RESERVOIRS.

can be ultimately traced to vegetable food; and the vegetable world is only the storehouse of the force emanating from the sun.

The only force existing on the face of the earth not traceable directly to the sun is that of the tides. The tides would exist if the fluidity of the ocean could be maintained, even though the heat of the sun was extinguished. The trade winds are also in part independent of the sun, the direction being due to the rotation of the earth. These, however, form but insignificant exceptions to the general rule, that the power available for the purposes of man can be traced to the sun as the great source.

The sun, then, is the great worker, and the slave of man. He works every spinning-jenny in our manufacturing towns, forges every shaft, propels every ship, turns every water-wheel, and moves the limbs of every man and animal. Man, with the power of intellect, merely stands over him with the rod of dominion, and directs his giant strength to suitable tasks. In one point of view, we may well exclaim, "What is man, that thou art mindful of him? or the son of man, that thou shouldst visit him?" But the above views give new force to the declaration, "Thou hast crowned him with glory and honour; thou madest him to have dominion over the works of thy hands: thou hast put all things under his feet."

The triumphs of mechanical genius are the boast of our age, as well as the foundation of much of our national wealth; but how rude are the inventions of men compared to the adjustments of the Divine Mechanician in the solar system! We place a furnace on the ground, and by means of a system of boilers, cylinder, piston, levers, shafts, and wheels, are enabled, in the topmost story of a factory, to spin thread of gossamer fineness; and no intelligent person has ever witnessed the sight without being impressed with the marvellous dominion of man over the material world.

But how puny, after all, is this effort compared to that which the working power of the sun exhibits! Here the furnace is not placed a few yards distant, but ninety-five millions of miles, and on what a stupendous scale! This world, compared to the sun, is no larger than a single stone of St. Paul's compared to the whole fabric. It is one of the most difficult problems in practical mechanics to transmit power to a distance, and we have to employ the rude device of long shafts, as in factories; rope and drum, as in the case of railway inclines; or air-pumps, as in the case of atmospheric railways; and, after all, we can only act at a very limited distance. But the sun transmits its power many millions of miles without the aid of mechanical contrivances, and so smoothly and silently that we are almost unconscious of its working. It is by the impalpable lever of the sunbeam that the central power acts on our distant globe.

And mark how conveniently concentrated the sunbeams are for our daily use. Were we under the necessity of relying upon the diffused heat of the sun, it would be very difficult to apply its power. We might, no doubt, employ glasses to condense the rays of the sun upon steam-boilers, but the result would be more curious than useful. We have, in nature, a far more useful condensation, viz., fuel, which is just a vehicle for the sun's power. The waterfall is another convenient form of condensed power supplied to our hand. The sun's rays are imprisoned by the very act of raising the water to a higher level ; or, in other words, they are transformed and condensed into mechanical power.

This wondrous mechanism, by which the power of the sun is transmitted to our globe, and conveniently stored up for man's use, is to us a far more striking illustration of divine intelligence, than the mechanism of the solar system by which its stability is maintained.

The attention of men has been almost exclusively turned, since the days of Newton, towards this one point, as the grand proof of a presiding intelligence. But it may be questioned whether a divine intelligence might not as well be proved from the order of a system, one element of which was, that the present arrangement was not permanent, but only a cycle in some grander evolution. Were it proved, as some astronomers hold, that the solar system and the system of Saturn's rings are hastening to a dissolution, or rather fulfilling their *rôle* as parts of a grander scheme, should we be forced to abandon the whole as proving a divine intelligence ? There may be as much beauty and order in a mutable as in a permanent system, and where these elements are found, we have proof of intelligence.

The argument for intelligence rises to a higher species of proof, when we consider not merely the beautiful adaptation of one part of the material machine to another, but also the correlation of the machine to life and intellect. Now, the most marvellous of such correlations are those which are furnished by the sun, as the grand moving power on the face of our globe, and a moving power in virtue of its light and heat. Gravitation is not properly a moving power. It is only a condition, not a source of power to man. No doubt, if we raise a stone it will fall by gravity to the earth, when we drop it from our hand; but the great want of man is a power to raise the weight, and what we mean by a moving power is just one that can raise a weight. Now, the sun, as the great central furnace of the machine, is the prime moving power of the world—the lifter of every weight. He drives the great shaft of the machine, and all that man does is merely to put on a belt upon the drum when he wishes to utilise the power.

Man's body may, no doubt, be regarded as a working machine, its power being derived, as that of all other machines, from the sun; but its chief function is, as the vehicle of intellect, to direct the illimitable power at his command.

Man, valued simply as a source of mechanical power, is worth only three tons of coals. Let a man labour all the days of his life, and his labour will not exceed the mechanical power stored up in a single truck of fuel. Nothing can illustrate more strikingly the superiority of intellect, and afford a more convincing proof that the *differentia* of man is mind, and that his body is but an accident.

It was needful, however, that his body should, to some extent, be a source of power to open the sluices of energy stored up in the material world around him. The engine-driver needs bodily strength to work the valves, and so direct the giant power that is to propel a floating palace across the ocean with the swiftness of a race-horse. Intellect thus enables man to multiply indefinitely the strength of his body.

THE SUN.

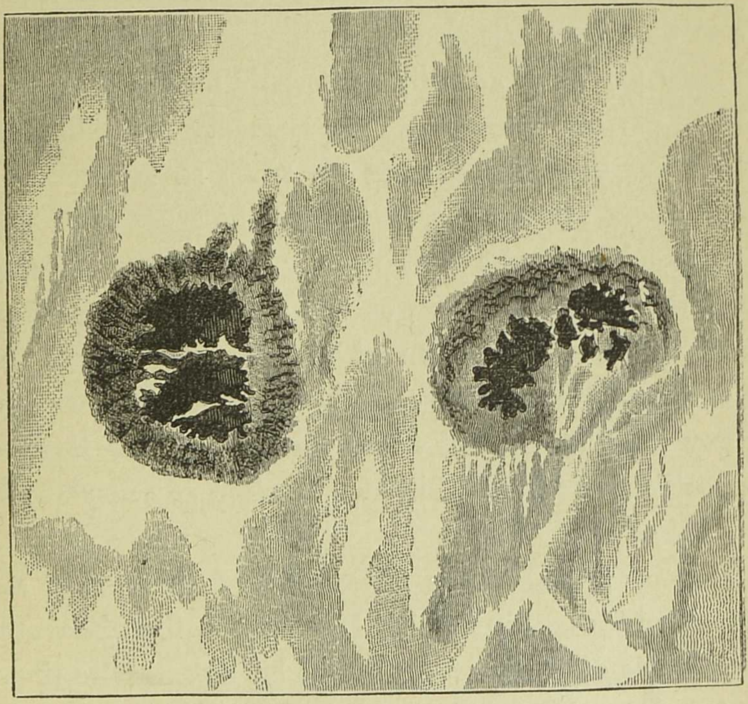
CHAPTER IV.

HIS STRUCTURE.

LET us now turn to the structure of the vast furnace which supplies us with all our moving power.

It is strange how little attention has been paid till recently to this function of the sun. The human mind seemed to be quite satisfied with the grand discovery of Newton, that the sun is the centre of gravitation in the solar system; and can we wonder that it should, for a time, be entranced with the discovery, so that still more interesting relations of the sun to man should be overlooked? The attention of physicists has now been fairly arrested by this subject, and much light has already been thrown on the constitution and structure of the sun.

Much of our ignorance of the constitution of the sun may be ascribed to the awe and mystery with which it has always been regarded. The oriental worshipper of the luminary would shrink from the idea of unravelling the mystery of the universe by too curious a scrutiny, and a similar feeling appears to have restrained the prying eye of the astronomer. The spell of mystery is now



SPOTS (OPENINGS) ON SURFACE OF SUN.

broken, and the sun must submit to examination like any of his subject planets.

It is almost incredible that there is no authentic account of observations of the spots on the sun till a very recent period. Millions of worshippers for ages hailed the rising sun, or bowed their faces at his setting; and yet these spots seem never to have been observed, though quite noticeable often by the naked eye. One would almost be inclined to conclude that they are a modern feature of the sun, were it not that we have many parallel cases, where obvious facts have been overlooked for successive generations. Most people will be able to corroborate this fact from their own experience.

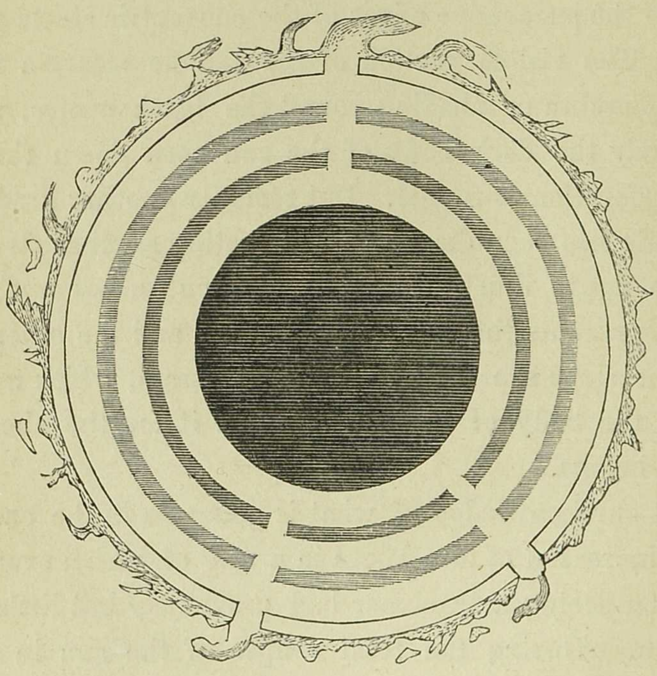
How few have actually seen spots on the sun, though every person must have had many opportunities of observing them! There is no town so favourably circumstanced for the observation of the spots as Glasgow. The cloud of smoke that usually hangs over it, mingled with the fog of the river, affords an admirable darkening medium for viewing them with comfort. Yet how few of the inhabitants have seen them, though there are not many days in winter which do not present favourable opportunities for noticing objects often so conspicuous to the naked eye.

It was probably the advantages of the murky atmosphere of Glasgow that led Dr. Wilson, the discoverer of the nature of the spots, to direct his attention to the subject. His theory is now almost universally adopted, though the recent results of spectrum analysis will probably lead to some modification.

The spots are perforations in the luminous envelope of the sun, through which we see its dark body. This envelope or photosphere may be conceived as a stratum of luminous cloud, floating in a transparent atmosphere. But when we look down through the perforation, we see the edges of other strata, apparently non-luminous. Two of these have been detected, and there may be many more. The sun may then be conceived of as composed of a dark central body, encompassed by successive envelopes or shells, suspended at different heights in the atmosphere—the uppermost being the one which forms the luminous disc of the sun. In looking down the holes we see the successive edges of the concentric strata of the sun. The visible portion of the middle stratum forms the penumbra or shading round the black centre, which is merely the dark body of the sun seen down through the perforation or funnel. But recently another gradation of shade has been discovered, indicating another stratum.

The figure illustrates this. The outermost unshaded ring represents the luminous stratum, and the other two interior rings are the non-luminous strata, which may so shade the body of the sun as to fit it for the abode of living beings.

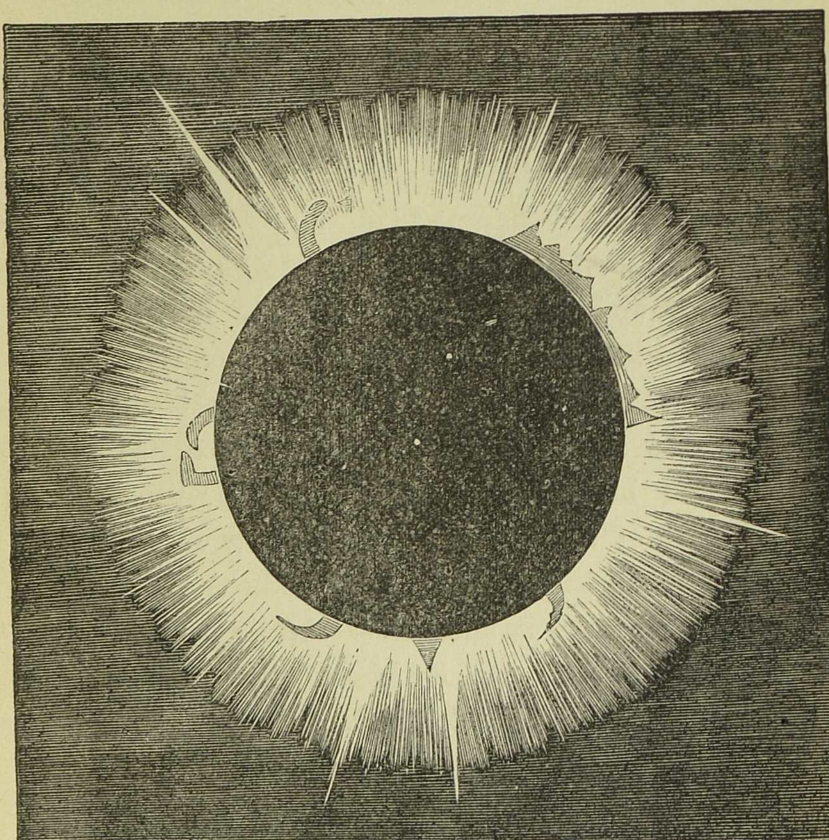
But our knowledge of what is going on in the sun has been increased of late years in a way of which even the most far-seeing astronomer had previously but little conception. During the total eclipse of the sun in July, 1842, certain rose-coloured protuberances were noticed projected from the edge of the dark moon, which at these times hides completely the whole of the solar orb from view. Nothing is then seen but a faint glory, or corona, encircling the black moon. During the next eclipse, which occurred in 1851, the same phenomena were exhibited; but the form of the prominences was very different from those previously seen, while their position and number had also nothing in common. Various opinions were expressed about the composition of these coloured cloud-like additions to the usual photosphere, and for some time it was not certain whether they belonged to the sun or moon. However, during the



SECTION OF SUN.

eclipse of 1860, which was observed in Spain, they were conclusively proved to be solar appendages, the motion of the moon over the prominences being very plainly visible on two photographs of the eclipse taken by Mr. De La Rue, one at the commencement, and the other near the end of totality. But of what they were composed still remained a mystery.

Soon after this time it occurred to several astronomers that the application of the spectroscope, in future eclipses,

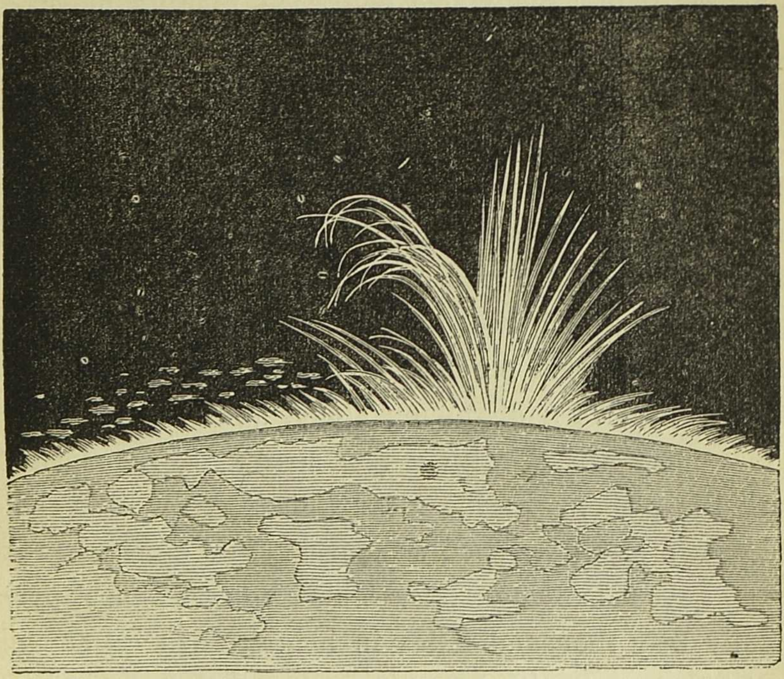


APPEARANCE OF SUN IN AN ECLIPSE.

to analyze the light of the prominences, would probably increase our knowledge of their composition. This little instrument had been previously employed in a most successful manner in analyzing the light of the heavenly bodies, including the principal stars and some nebulæ. During the progress of the great eclipse of 1868, which was total nearly seven minutes in India, the spectroscope was therefore employed with the greatest success. As soon as a prominence was brought on to the slit of the instrument, a spectrum of bright lines was seen, indicating that the light emitted from this prominence came from a mass of intensely-heated and glowing hydrogen gas, forced up from the chromosphere below to a height of nearly a hundred thousand miles.

Similar observations to those of 1868 have since been made over and over again, not only in succeeding eclipses, but in ordinary daylight. Delicate contrivances have been made to absorb the intense light emitted by the sun, the details of which it is not possible to explain here; but we may remark that the prominences on the edge of the solar disc can be now observed from day to day and from hour to hour without the intervention of the moon, as in an eclipse. While the astronomer is watching a prominence, it is frequently seen to alter its form to move about as if drifted by the solar atmospheric currents, sometimes at the rate of a hundred and twenty miles in a second; to dissolve gradually, and finally disappear altogether.

The force of these solar storms is of so great a magnitude, that it bears but a slight resemblance to that of terrestrial atmospheric disturbances, especially when it is considered that instead of wind and rain, the usual accompaniments of our storms, the moving matter on the sun consists of gaseous clouds, formed principally of hydrogen, heated so highly as to be in a state of incandescence. Occasionally the chromosphere, or the brilliant gaseous layer exterior, but close to the photosphere, is more subject to violent action than at other times; and



VOLCANIC ERUPTION IN SUN.

it has been the good fortune of an American astronomer, Professor Young, to witness a remarkable storm, or explosion, during the greater part of the time that it was raging. He was making an examination of the sun's edge on the 7th of September, 1871, especially of an enormous protuberance which had remained in the same position since the preceding noon. It was a long, low, quiet-looking cloud, composed of filaments nearly horizontal, floating above the chromosphere, but connected with it by several vertical columns of glowing hydrogen.

Professor Young left the telescope a short time, and on returning found the whole had been literally blown to shreds by some tremendous uprush from beneath. In place of the quiet cloud which he had left, the space was filled with vertical filaments rapidly ascending. Some had already reached a height of nearly a hundred thousand miles, and while they were watched, they rose with an almost imperceptible motion, till in ten minutes the uppermost had reached two hundred thousand miles above the solar surface. As the filaments rose, they gradually faded away like a dissolving cloud, and soon after only a few filmy wisps, with a few streamers, remained to mark the place. In the meanwhile, another little cloud had grown and developed wonderfully into a mass of rolling and ever-changing flame. This also rose almost pyramidally fifty thousand miles in height, then its summit was drawn out with long filaments and threads, and the cloud finally faded away and vanished like the other.

Such is a good example of what is daily occurring on the surface of the sun. How all this consumption of gaseous matter is renewed seems out of our power at present to account for ; some partial theories have, however, been suggested, but they have all been based on a doubtful foundation. That the Creator has provided some means for restoring that which has been consumed in the glowing chromosphere, although science has not yet been able to offer an explanation, is the general belief; for the most delicate measurements of the solar diameter cannot detect from year to year the slightest diminution in its magnitude.

THE SUN.

CHAPTER V.

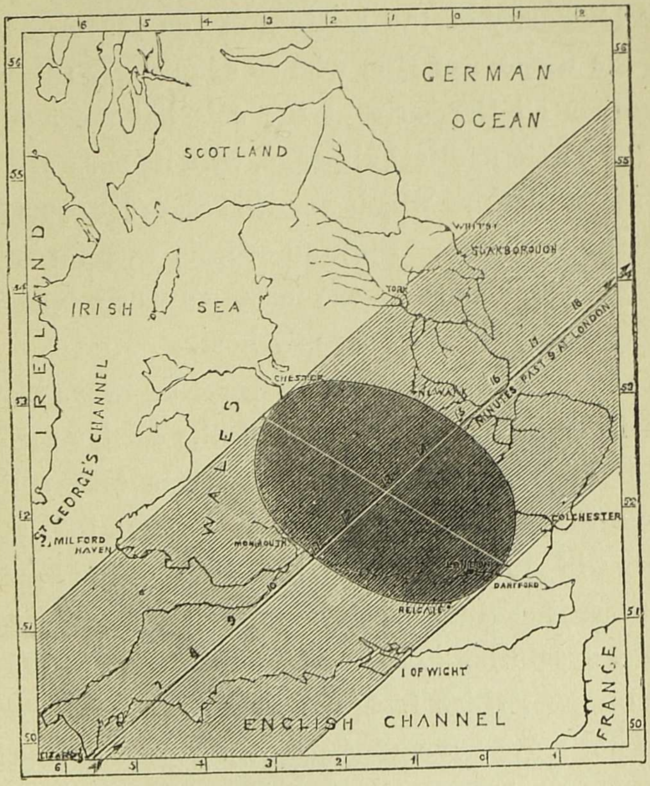
ECLIPSES.

WHEN the alarm of an eclipse is given in a Hindu village, the whole population turn out to avert the impending calamity.

The black disk of the moon encroaching upon the bright surface of the sun is believed to be the jaws of a monster gradually eating up the latter. Gongs are violently sounded, the air is rent with screams of terror and shouts of vengeance ; and all this uproar is made with the hope of scaring away the dragon from his dreaded purpose.

For a time their efforts are in vain. The glorious sun disappears gradually in the mouth of the voracious monster ; but, at last the increasing din seems to effect its purpose. The monster appears to pause, and, like a fish that has nearly swallowed the bait, but, on second thought, rejects it, gradually disgorges the burning morsel. When the sun is quite clear of the jaws, a shout of joy is raised, and the villagers disperse with the pleasing satisfaction that they have done the luminary a good service.

This is but a type of the human mind in its untutored



PATH OF ECLIPSE OF 1715.

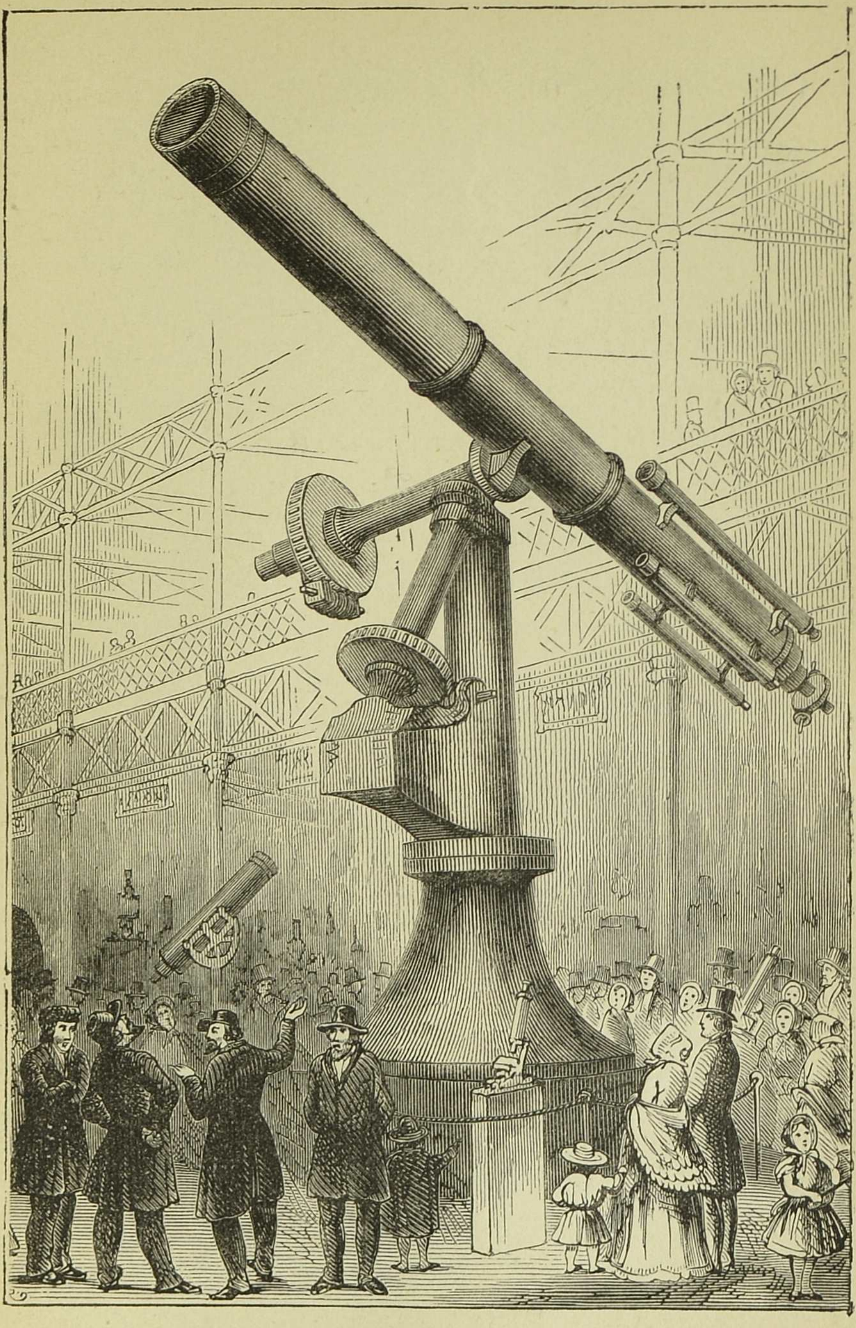
state, when it is unable to rise to the conception of a God whose glory lies in the orderly and regular evolution of His works of providence.

It is the power of predicting the time of eclipses that has divested such phenomena of their terror. The most ignorant Hindu could hardly but be ashamed of his superstition, and have his faith in the gong shaken, if the astronomer told him beforehand the precise moment when the monster would come and depart.

Eclipses, more than anything else, demonstrate the perfect regularity of the motions of the heavenly bodies, and of the wisdom of Him who so exquisitely adjusted to one another all the parts of the celestial machine. No doubt the whole nautical almanac, with its mass of figures, is full of predictions which manifest an order equal to that indicated by eclipses. Still, an eclipse, with its imposing phenomena, proclaims in the most emphatic manner the marvellous order of the heavenly host.

The chance of a person ever witnessing in his lifetime a total eclipse in any given spot of the earth's surface, is exceedingly small. The shadow forms only a narrow band on the earth's surface, and, though that strip of darkness will cross Europe six times during the remainder of the present century, yet comparatively few places will enjoy the spectacle. It is certain that none of the inhabitants of the British Isles will ever see a total eclipse if they do not move beyond their own shores. But if the shadow does not come to us, we have the alternative of going to the shadow.

It may, however, be asked, "Is it worth while to go out of one's way to enjoy the spectacle? We have seen eclipses very nearly total, and we can readily conceive one that is absolutely so. Would it, then, really reward



TELESCOPE IN EXHIBITION, 1851.

one to travel far to behold a sight which may differ so little from what we have already seen?"

We can give a very decided answer to this question. No approach to totality can give the slightest conception of the effect produced the instant that the last thread of light is extinguished. The light of the sun is so intense, that while the slightest part of the disk is visible, the darkness is by no means alarming.

The eclipse of 1857, which was nearly total, gave great disappointment to many who were led to expect something very appalling. Accounts of total eclipses were previously given, and it was a natural and popular expectation, that one so nearly total would produce effects very similar. But such was not the case. The darkness was no greater than that often produced by a passing cloud, and, in the case of many, the eclipse occurred without being in the least noticed. Partial and annular eclipses are now regarded as matters of mere curiosity, and a momentary glance upwards is regarded as all that is demanded in the way of attention.

It is far otherwise with the total eclipse. The gradual creeping of the moon over the disk of the sun, gives no preparation for the grand final effect when the last ray is quenched. It is felt not to be a matter of gradations, so frightfully sudden is the darkness. There is no comparison between a man nearly drowned and drowned altogether, or between a man half over a precipice and over altogether; so there is no comparison between a nearly total eclipse and one absolutely total. As it is the last straw that breaks the back of the camel, so it is the extinction of the last line of light that produces the darkness that may be felt; and the "feeling of the darkness" is hardly a metaphor, as the borders of the terrible pall thrown over the earth can be actually seen swiftly floating past in the air.

In these days, when the passion for travel is so strongly developed, people are ready to go any distance to experience a new and strong sensation. They do not scruple to traverse the Atlantic, that they may gaze on the Falls of Niagara, or shoot the rapids of the St. Lawrence; but such sights are not to be compared to a total eclipse, if measured by the power of stirring strong emotion.

In an eclipse all things combine to deepen the effect; there is nothing out of keeping with the grandeur and awfulness of the spectacle. In viewing the Falls of Niagara, there is much to tone down the feelings of awe and wonder. Familiarity has destroyed man's reverence; merry, laughing, picnicing parties dispel the charm. Blondin exhibits his tight-rope antics in their very presence. The very birds despise their terrors, and dash heedlessly into the spray, to catch the stupefied fish as they come tumbling down the liquid arch. The descent of the rapids of the St. Lawrence, however daring the exploit may at first seem, fails, from the requisite accessories, to produce a very powerful sensation. Even when shooting the Long Sault, there is no overpowering feeling. The Indian at the wheel, with his imperturbable matter-of-fact every-day expression; the old traveller, not caring to rise from the breakfast-table to look out on the tumultuous rush of waters; the air of security around—all combine to break the spell of that wonderful feat.

It is quite different in the case of the total eclipse. All nature sympathizes with and enhances your feelings of awe and mysterious apprehension. The earth, seas, sky, assume a lurid, unnatural hue. An unearthly silence is felt at the moment of totality. Every living thing catches the influence, and cowers under the great blank in the heavens. Beasts of burden lie down with their loads on the road, and refuse to move on. Swallows in their bewilderment dash against the walls of houses, and fall down dead. The dog drops its bone from its mouth, and does not venture to seize it again till the light returns. Chickens seek the shelter of the parent wing; and even ants halt in their tracks with their loads, and remain immovable till the shadow is past.

With such accessories as the above, it cannot be wondered at that, in the case of man, however impassive his nature may be, a total eclipse never fails to produce feelings of mysterious awe.

The most learned savant, as well as the most unsophisticated peasant, confesses to such feelings. Even Mr. Airy, the astronomer-royal, the impersonation of the calm and the abstract, confessed to very curious and indescribable feelings.

It is, however, when men are massed together that the finest opportunity is afforded for watching the psychical effects of an eclipse. Such an opportunity was enjoyed by the French astronomers when observing the total eclipse of 1842 at Perpignan.

The observers were stationed on the ramparts with their instruments ; the soldiers were drawn up in a square on one hand, and on the other the inhabitants were grouped on the glacis, so that the station commanded the full view of twenty thousand upturned faces. The astronomers did not fail to watch the phases of feeling in the crowd, as well as the phases of the eclipse. The moment that the people, with smoked glasses to their eyes, marked the shadow's arrival at the sun, giving, as it did, the effect of an indentiture in the sun's disk, they raised a deafening shout of applause, much in the way in which they would salute a military hero, or a popular actor. The moon gradually crept over the sun, and for a considerable time there was nothing observable but the ordinary loquacity of a French crowd.

As the eclipse drew towards totality, the murmur of twenty thousand voices rapidly increased, each one telling his neighbour of the strange feelings coming over him. Suddenly the last filament of the sun's disk was covered, and at that moment a deep, prolonged moan, as from one man, arose from that vast crowd. It was like the stifled groan of the multitude witnessing a public execution, at the moment that the axe or the drop falls. The moan, however, did not mark the climax of high-strained feeling. The dead silence that ensued was the culminating point. Not a whisper was heard, not an attitude was changed, as with the rigidity of a statue each man stood and gazed upwards. So unearthly was the silence, that the beat of the chronometers was heard with painful distinctness. The heart of the universe seemed to cease its throbbings. Nature had fallen into a state of syncope.

For two and a half minutes this dreadful pause continued. At the end of this period a thread of light broke forth; the tension was at once relieved, and one loud burst of joy rent the heavens. They could not restrain their transports of happiness, now that the dread, undefinable woe had passed over. They did not care now to look at the final phase of the eclipse, as the darkness wore off; they had beheld the crowning spectacle; they would not weaken the impression by looking at the partial obscuration, and soon the whole crowd melted away, leaving the astronomers to continue their observations alone.

THE SUN.

CHAPTER VI.

A TOTAL ECLIPSE.

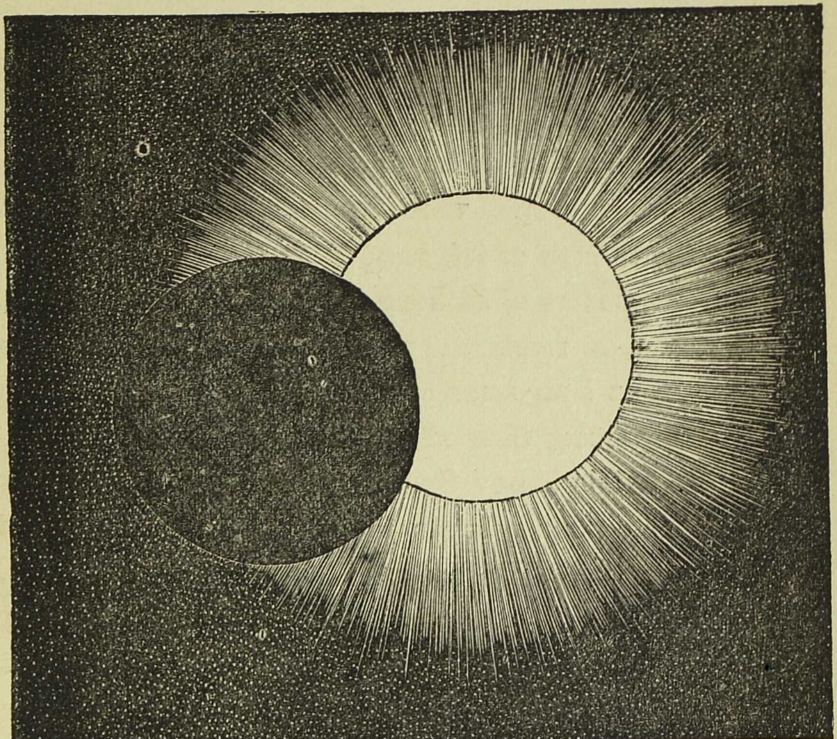
OUR party of four posted in a little hut on the culminating edge of the Spanish Pyrenees, amidst scenery of no ordinary wildness and grandeur; alone, and yet with no impression of solitude.

Our days were spent in the hut and its little enclosure, endeavouring, as the weather permitted, to adjust our instruments; now and then strolling, as opportunity presented itself, into the neighbouring villages.

The morning of the day of the eclipse was as unpropitious as cloud and rain and mist could make it.

By noon matters began to mend, the weather clearing up rapidly. Soon after noon the whole population of the country turned out, and assembled as near as they could to our hut and the large telescope.

At one o'clock, to our great relief, not a cloud was to be seen in the heavens from the horizon to the zenith, with the exception of a dense mist which enveloped, as usual, the shoulders and summit of the Gorbea mountain. And now, among the spectators there commenced



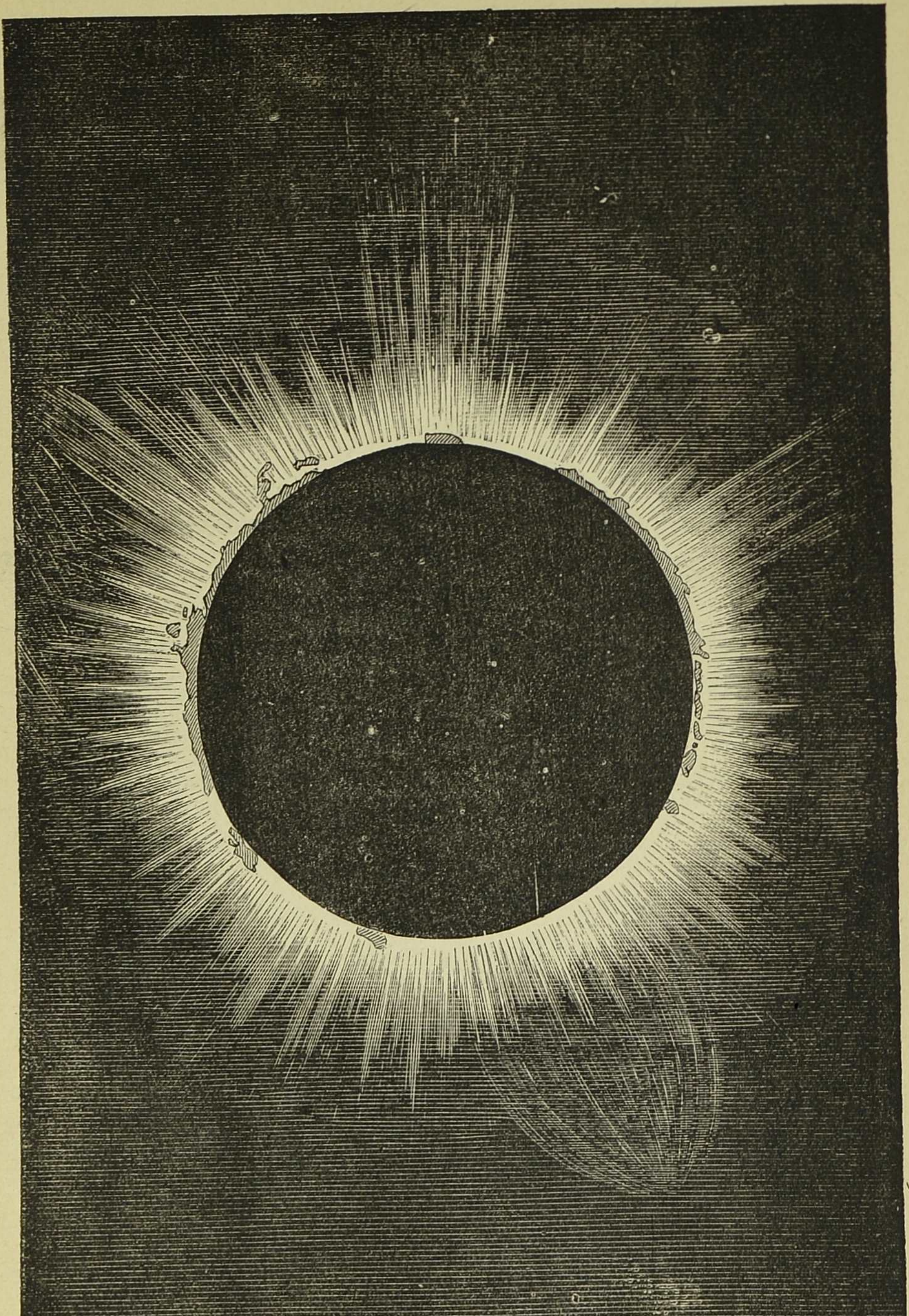
MOON APPROACHING THE SUN.

a very active demand for pieces of smoked glass, which we gratified to the best of our power. We heard also the bells of the parish church at Izara ringing with great vigour, for the priests there had considerately undertaken to protect their flocks from the impending evils of the heretics and the eclipse!

The contact of the sun and moon was well observed with the telescope; but the remaining part of the disc of the dark moon itself thus striking the sun was wholly invisible. In this respect our illustration is ideal. As the black moon silently crept over the sun's face, its uneven mountainous character became clearly displayed in the telescope. There were several spots on the sun, and faculæ, or huge mountainous ridges of its luminiferous envelope, were heaped up in abundance towards the eastern or left-hand limit.

In three quarters of an hour the landscape had become perceptibly dim, reminding us of the light of an autumn sunset. In an hour some of the assistant engineers were observed to shrug their shoulders and put on their oil-skin coats, while many Spaniards, who sat on the grass watching the eclipse, began to push themselves into the heather to warm their backs. About ten minutes later, compliments began to be freely passed among our party on the grim, sepulchral look of each other's countenances, and excitement became general. There was still ten minutes before the last light of the sun was extinguished. Now we saw, or as it were *felt*, the mighty rush of gloom which came sweeping at an awful speed from the N.W. like a storm over the waters, and yet suddenly wrapping objects and men in an unexpected silence and windless calm.

The ordinary invisible crown-like glow which surrounds



THE SUN IN ECLIPSE.

the body of the sun now became visible. It is called the corona. In an instant it broke forth in all its beauty, appearing like a fringe of golden fire round the black moon. Hundreds of Spaniards who lay warming themselves in, rather than on, the heather, now sprang up as if electrified, shouting, "Mire a la luna! Mire a la luna!" "Look at the moon! Look at the moon!" We quieted them, and they lay down again watching in silence.

But other circumstances beside the apparition of the corona contributed to the grandeur and excitement of the scene. Our entire distant horizon, where visible, became tinged with such gorgeous hues as are not seen by mortal eyes on other occasions. The distant hills were blue, the immediate foreground was orange. The sky above them for several degrees assumed a strong rosy tint, and then rapidly shaded off to a dark indigo blue. Near to the black moon and the corona, planets and stars were shining. The moon, like a round black patch, hung in the mid air. The aspect of things was unearthly.

Turn to the picture of the eclipse.

The black circular patch represents the moon as seen with the naked eye at the time when the eclipse was with us most nearly central. The bright radiated ring surrounding it, is the corona, and from it proceed five outlying appendages of peculiar form.

The effects produced on animals were very various. Horses and dogs appeared to be unconcerned. The former continued to graze and the latter to eat. Not so with a large assemblage of sheep; they divided themselves into small flocks and scampered off towards their several homesteads. Small birds were terribly frightened, some ran among the spectators, and two, as a cruel reward for their confidence, were caught. An eagle came wheeling in disagreeable nearness round the head of one of the assistants.

Such, then, were the remarkable, not to say the sublime, phenomena of the eclipse. Alas! they were almost as evanescent as they were grand: for three minutes only they were beheld in astonishment, and then they vanished as suddenly as they burst on our view. The returning light came, to our regret, and yet, in a certain sense, it came also to our relief.

The people, who during the last two minutes had been enveloped in profound silence, now became animated with the hum and the movements of hundreds of men and women.

THE MOON.

THE MOON.

CHAPTER I.

HER LANDSCAPE.

ON our globe everything is delicately adjusted to the cosmical laws that have sway over it as a member of the solar system.

The very curve of the snow-drop, as it bends its head, is regulated by the attractive power of the globe. The flower could not thrive in a world which attracted more or less. A slight change in the constitution of the atmosphere, or in the alternation of night and day, would be fatal to many forms of life. Did a comet come into collision with our earth, so as to change its axis, new conditions, wholly destructive to a wide range of animal and vegetable life, would be introduced.

If life exists in the moon, there must be special adaptations corresponding to its physical constitution. The fact that bodies are more than five times lighter in the moon than on the earth, would admit of their being on a much more colossal scale.

Trees, for example, on our globe, throw out their branches timidly, lest they break with their own weight. They carefully keep within the breaking point, and so nicely is this adjusted, that when, from any extraneous cause, they become overloaded, they are apt to come away with a crash; as in the case of the ancient forest in Italy, which recently had every tree stripped of its branches by the icicles with which they were loaded. A slight wind was all that was necessary to convert into bare poles the stately trees of a forest that had stood for ages.

In the moon, however, trees could safely throw out their branches to a much greater extent, simply for the reason that they are so much lighter.

It is a great feat in architecture to construct a spire or factory chimney a few hundred feet high, and when such structures exceed a certain height, there is danger of their toppling over, or of being crushed by their own weight. But in the moon, the colossal chimney of Glasgow would be altogether dwarfed, standing side by side with the chimneys of the lunar factories.

Then, as to the alternation of day and night, how singularly constituted must the forms of life be to bear a fortnight of unmitigated sunshine, and then a long dreary night of similar length! Scorching is avoided, on our globe, by our turning away from the central fire after

LANDSCAPE IN THE MOON.

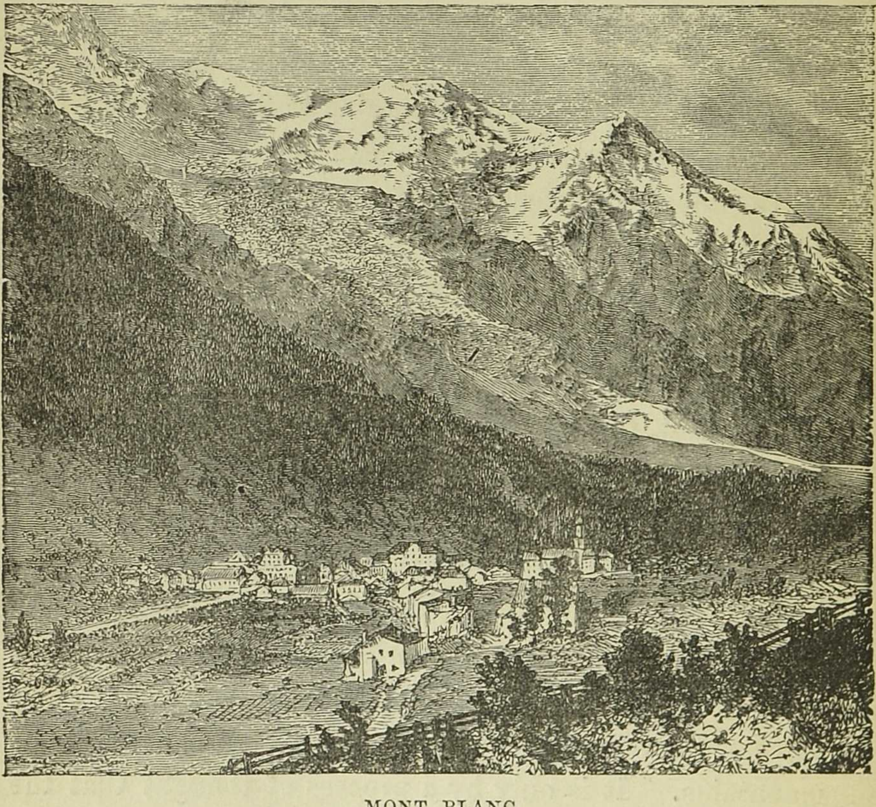
twelve hours' exposure. During the night we are agreeably cooled, and prepared once more to hail the genial light and heat of the sun. But were our summer days doubled in length, the heat would be intolerable, and all things would languish and die. How strangely constituted must animal and vegetable life be in the moon, to bear the long scorching of a day equal to fourteen of the earth's days!

We have not, however, been able to discover any living forms in the moon. But we can detect on the surface of the moon a configuration that conforms to the plan on which the earth's surface is modelled.

When you first look at the moon through a telescope, even though it be an excellent one, you can hardly fail to be disappointed.

No doubt, the surface of the moon will excite surprise by its curious and novel aspect, but it will fail to give you any idea of magnitude. You may tell the beholder that the little specks of light he sees at the edge are mountains higher than Mont Blanc, but he has no feeling of the reality. And many a one who has looked through a telescope comes away as incredulous as ever. The objects descried through the telescope are not *seen* to be mountains. It is only by a process of thought that the mind is convinced that they are mountains.

The maps in relief, hung up in the hotels in Switzerland, though faithful models of the Alps, do not convey the impression of magnitude. Even the gigantic model in the library of Zurich, with its glass lakes, fails to give you this impression. But look through the library windows at the actual mountains before you, and you fully realise the magnitude, even though the picture on the retina is larger, in the case of the model, than in that of the actual mountains.



MONT BLANC.

Now, the perspective we have of the moon is such that it produces only the effect of a model, and, when looking through a telescope, we have the same difficulty in transmuting the stucco-like prominences into mountains, as we should have in converting the hotel model into a real Alpine range.

We must call in the aid of imagination before the landscape of the moon can stand out before us with the reality of a terrestrial scene.

Let the reader join us in a lunar excursion, and we shall endeavour to trace out the points of resemblance and contrast in the scenery of the earth and moon. Let us wing our flight from this globe, and mark the changes in the aspect of the moon as we gradually approach. We are soon able to discover a diversity of colour.

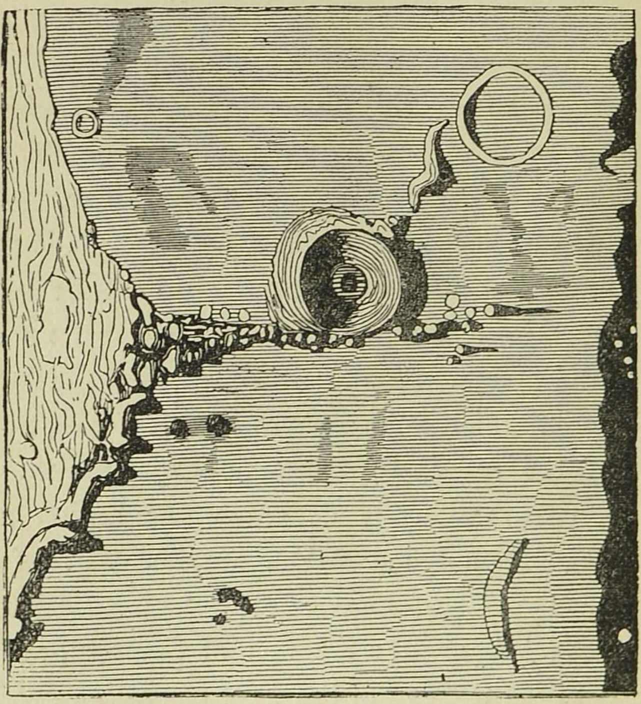
From the earth's surface the blaze of light is so great, that only difference of shade can be discerned; but as we approach, things assume the aspect of real mountains, valleys, and plains. We soon discover that the dark parts in the moon, which fancy shapes into the eyes, nose, and mouth of the face-in-the-moon, are vast plains. They are not, now, uniformly dark, for one region assumes the aspect of ploughed fields, another that of a vast savanna.

The district known as the Sea of Serenity, and corresponding to the left eye of the face, has a rich green, as if clothed with luxuriant grass, or covered with vast forests of pine.

We shall not alight upon the forest, but shall choose rather the Sea of Showers—the darkest part of the moon's surface, and corresponding to the right eye.

We find here good footing, for it is neither a forest nor a sea. For hundreds of miles on all sides there is a dead flat. Here and there solitary peaks, like that of Teneriffe, start from the plain, unconnected with any mountain-range. They rise from the vast prairie as abruptly as the pyramids do from the sands of Egypt.

But as we travel on, we descry mountain-ranges rising

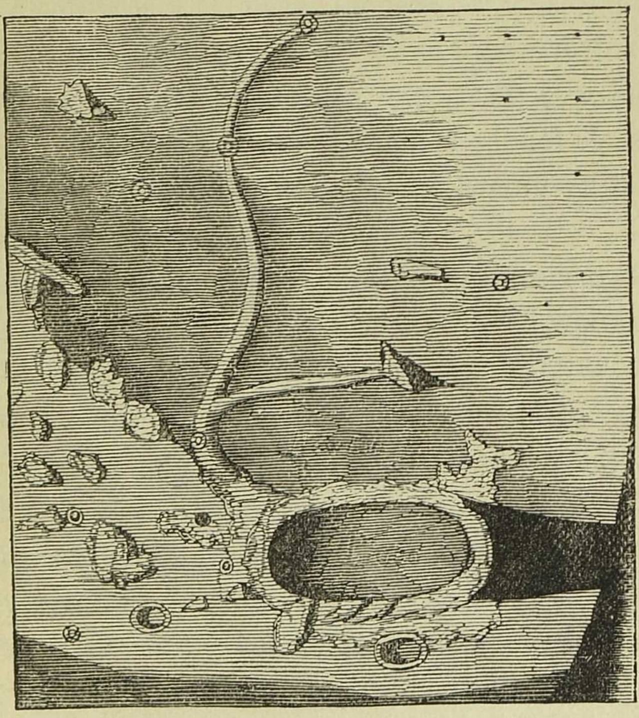


MOUNT ERATOSTHENES, AS SEEN FROM THE EARTH.

in the horizon. Before alighting on the moon, we could distinctly note the contour of these ranges. While some stretched for hundreds of miles in nearly straight lines, there were others, and these the most numerous, that formed a vast circle.

We shall make for one of the most regular of this last class—viz. Eratosthenes. But, before reaching the foot of this range, we must pass over bright rays, radiating from the circular mountain, Copernicus.

These rays are one of the most marked features of the



MOUNT PLATO, AS SEEN FROM THE EARTH.

moon, as seen through a telescope. Oken speaks of mountains as the organs of a planet, and certainly these mountains may not inaptly be represented by a star-fish with its diverging rays. But now we can examine the mystery, and we find that the rays are trap-dikes, rising little, if at all, above the level of the general surface. They appear as bright rays through the telescope, merely because they reflect the light better than the rest of the plain. No mould or verdure has covered them up, as the lava of Vesuvius has been by the vine-clad slopes. Not even does the lichen grow upon them, and hence they are clearly discernible from the earth. We can even discover where one dike cuts another, and tell which is the older of the two. We can thus draw up a chronological scale for the convulsions of the moon.

But let us pursue our journey onwards to our destination, Eratosthenes. This circular mountain, or rather range of mountains, is thirty-seven miles in diameter; and we know its dimensions more accurately than those of the mountains of our globe.

The ascent is by a comparatively easy slope. We do not feel the want of mules, for we combine the strength of a man with the weight of a child. We can bound from rock to rock more lightly than the chamois, and can leap across chasms six and a half times broader than any we could venture to take on the surface of the earth. Were it not for this convenient lightness, the task would be impracticable. The rocks have all their natural angularity. There has been no weathering to mitigate the roughness; and chasms and sharp peaks face us at every turn.

We at last gain the summit, seven thousand five hundred feet above the plain outside. An astounding spectacle presents itself when we view the interior of this vast volcanic crater. The rise on the outside of the rim is gradual, but in the inside it is almost perpendicular. As we cautiously creep to the edge, we see plumb down fifteen thousand eight hundred feet, which is the height of Mont Blanc above the sea. Let us take a stone—a large block can easily be lifted—and drop it over. How long it hovers in the air! It descends so slowly—five times slower than upon the earth—and it has so far to descend. Did we listen ever so long, we should hear no reverberation from that profound depth.

In many places around this circular mountain wall, there are traces of terraces. In fact, the whole is a vast amphitheatre seated with terraces. In the centre of this crater a mountain rises many thousand feet in height. Let us transport ourselves to the summit; and, as you look around, you find yourself imprisoned within a perpendicular wall, fifteeen thousand eight hundred feet in height, and eighteen miles distant on all sides, with no possibility of egress. There is no gap in the wall, no outlet by which you may escape.

On the summit of the central cone on which you stand there is a lesser cavity, through which the ashes and lava, of which the cone consists, were ejected. But all activity is past, and eternal silence reigns. You stand on volcanic ashes, but you do not suffer the inconvenience of ascending the cone of Vesuvius. Thanks to the weak attraction of the moon, you can tread on the treacherous slope without sinking.

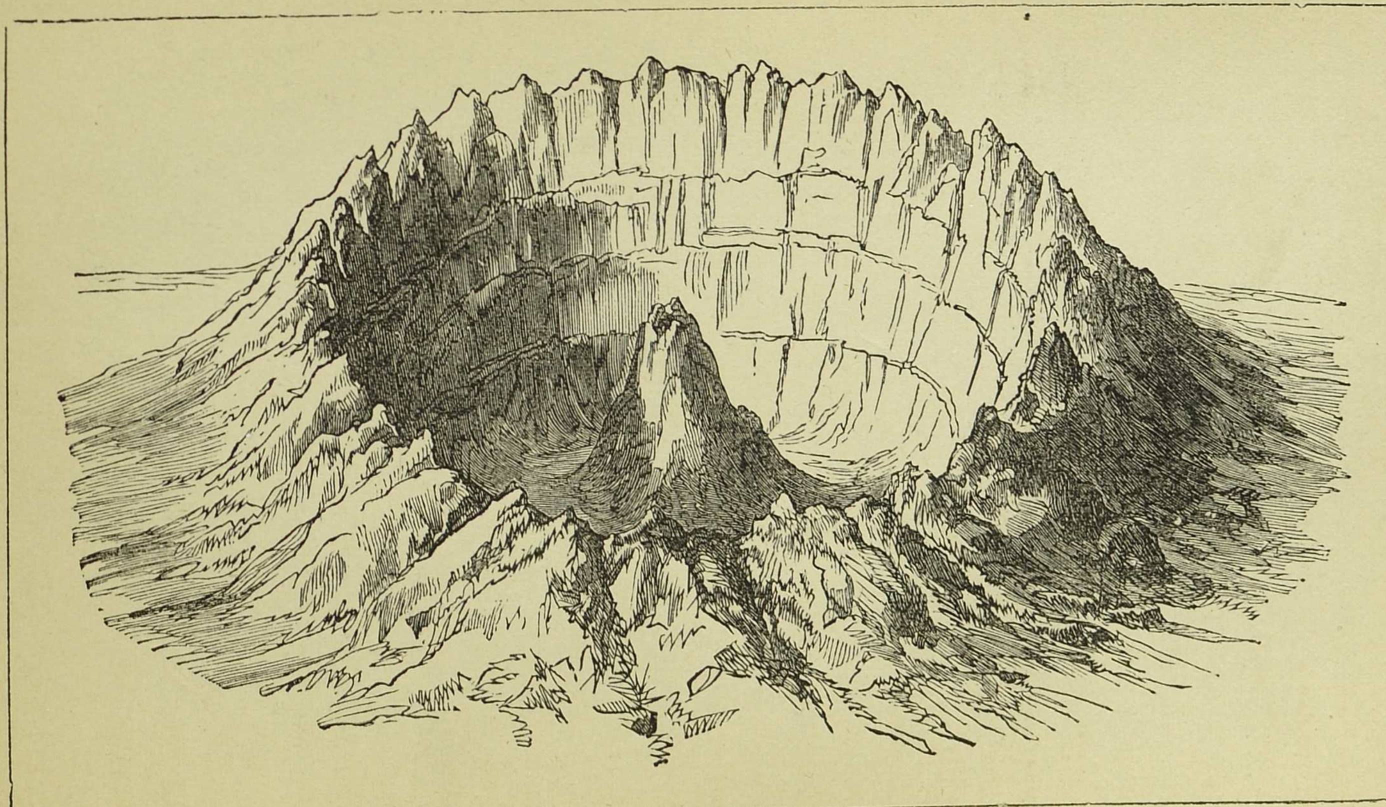
Now this singular formation is not singular in the moon. It is the grand feature of the lunar surface. That surface is divided into the dark plains and the bright alpine regions, and, in the latter, the grand characteristic is the circular form with the central cone.

These craters are of various dimensions. Some are fifty or sixty miles across, others are only a few hundred yards.

Now, do we find anything corresponding to this on the earth? It is plain that our active volcanoes only feebly represent the lunar craters. The volcanic apertures on the earth are only small craters at the top of volcanic mountains of no great dimensions, such as Vesuvius. The terrestrial approximations to the typical form are only like the undeveloped limbs of animals, pointing to the more perfect. Among the older formations, however, we find indications of the lunar circularity. In Auvergne, for example, there are some illustrations, and probably, at one time, they might have been very numerous. Successive upheavals, however, and various denuding influences have obliterated the distinctive features, and it is only in a few cases that we can trace the typical form. Monte Venere, at Rome, presents a very fair specimen, being the central cone of a large crater.

As in the morphology of plants, we detect, amidst diversity, the same typical form of the leaf, so we find in the moon endless repetitions of the typical crater with the central cone.

There are, for example, walled plains of vast extent,



CRATER OF ERATOSTHENES.

some of them being as much as a hundred and fifty miles in diameter. They differ from the typical crater only in this, that the enclosed part is a plain, instead of a concavity, and that there is no central peak.

Again, extensive ranges of mountains assume a semicircular form, and when the vast dark plains were regarded as seas, these semicircular forms were called bays or gulfs. But this semicircular form evidently points to the circular typical form.

Again, some of the craters are without any walls or rims, and in others the floor of the crater is convex, though in all cases it is sunk below the level of the surrounding country. But it is not merely the more prominent features that conform to the crater type. On minute inspection, we find that the whole surface has a crateriform structure.

If you throw successive handfuls of pebbles into a pond, you will see, at the same time, circles interlacing with one another, and smaller ones diversifying, in every imaginable way, the larger ones. Precisely such a spectacle is presented by the structure of the moon.

Theories of volcanic action have been proposed to explain all this; but we cannot linger longer on the summit of the central peak, and as there is no other mode of egress, we shall take an imaginary flight over the encircling wall, and again alight on the vast savanna from which we ascended.

Let us direct our steps to the lunar Alps, a very lofty range of mountains skirting the Mare Imbrium.

In passing along the plain, we come to interruptions like the crevasses in a glacier, only they are much wider, more regularly formed, and of unfathomable depth. They present exactly the appearance a trap-dike would do, if quarried out. These rents, or *rills*, as they are termed, cross each other in such a way as to produce fantastic forms. In one plain the letter H can be easily detected, and in another Z. There are, besides, many Chinese-like characters.

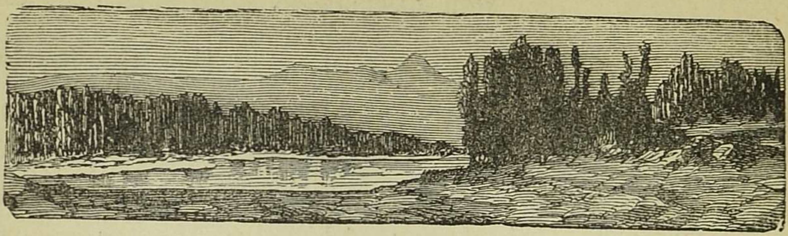
The first observers imagined that they were roads or canals. The most probable explanation is, that they are rents in the moon's surface, which have never been filled up with lava. They correspond to the white radiating streams which we have already noticed, and which are universally held to be pushed up through the rents. We can readily conceive the cracking of the surface without a subsequent filling up. The trap-dikes in the crust of the earth, in many cases, plainly indicate that the lava with which they are filled up was not the disruptive power by which the rents were caused.

With our newly-acquired buoyancy, we may attempt to clear the rill, as it is a small one; and, now that we are on the other side, we pursue our journey to the base of the Alps, and the first thing that strikes us is, that the cliffs, fronting the plain, rise, almost perpendicularly, from the base. When, however, we go round, and take them in the rear, we find that the ascent is comparatively easy. This leads us at once to a remarkable analogy.

On the surface of the earth we find that the precipitous sides of all great mountain-ranges face the sea. The terrestrial Alps, for example, have their steep side towards the Mediterranean. Those who have crossed the Alps, for example, by the St. Gothard, will remember the long, gradual ascent from Fluelen, through the canton of Uri, and the sudden descent and terrific zig-zags down the Val Tremola to the plains of Italy.

All the ranges in the moon have their steep sides, in like manner, towards the so-called seas. If we cannot admit that they are seas now, is it not probable that they may have once been seas? If all our seas and oceans were drained, the surface of the earth would present precisely the same spectacle that the moon does. But do we know of any draining cause?

Let us only suppose that the centres of figure and gravity were at one time coincident, that it was internal convulsions, of which we have such numerous proofs, that, at a subsequent epoch, changed the centre of gravity, and we have at once a cause adequate to the effect.



THE MOON.

CHAPTER II.

HER INVISIBLE SIDE.

A RECENT discovery has shown that the non-existence of an atmosphere in the moon's visible side does not at all imply that the other is equally destitute of one.

The moon constantly turns the same side to us. She does, indeed, as if to tantalise us, show a small portion of the other side. She turns round at one time the western edge, so as to show us a few more mountains and craters, and then at another the eastern; but it is only a few degrees that she thus reveals. It is by this libration, as we have seen, that we are able to take stereoscopic pictures of her disc.

She turns constantly the same side to us, from the simple circumstance, that she rotates once upon her axis, in the time that she performs a revolution round the earth.

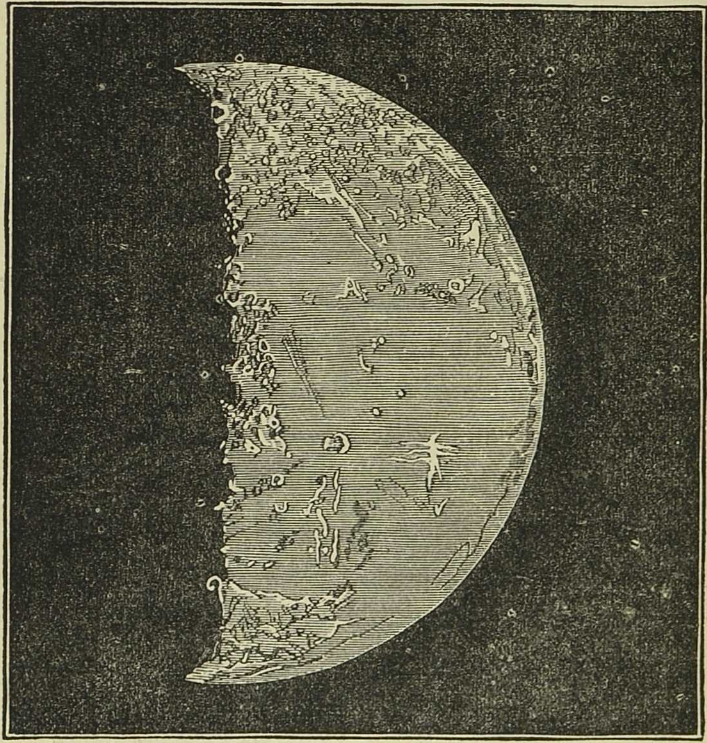
It at first sight appears like a contradiction, to say that she turns round upon her axis, and yet that she never shows us but one hemisphere. Does not rotation consist in turning round to us all sides in succession? This has always been a puzzle.

The perplexity arises from the position we occupy. If we were without, instead of within the circle she describes in the heavens, there could be no misconception. The inhabitants of the other planets see her turn in succession all parts of her circumference to them. In the course of twenty-eight days they can scrutinise every part of her surface. This arises from the same reason, that a person, in the centre of a circus, sees only one side of the horse galloping round the circumference, while the spectators beyond see both sides in succession.

Until lately, no conjecture could be formed of the state of things on the other side of the moon. It was regarded as one of those inscrutable mysteries which it would be folly to attempt to unveil.

Human genius has triumphed over the difficulty, and has thrown a marvellous light on that which has hitherto been involved in deepest darkness. And, in such cases, one feels at a loss which to admire most—the wonders of God's works, or the genius with which He has endowed man to explore these works.

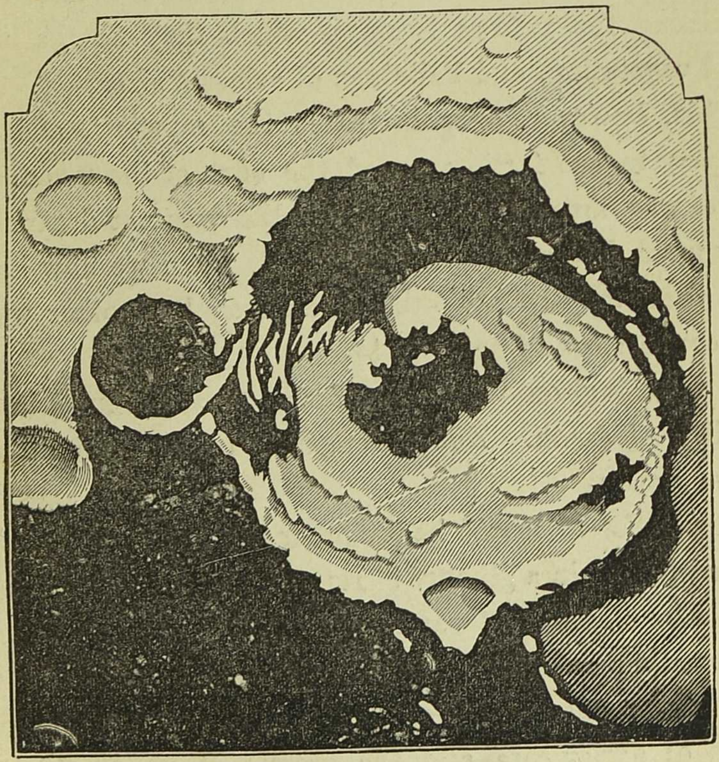
The scientific statement of the solution is, that the moon's centre of gravity and her centre of figure are not coincident, the one being distant about eight geographical miles from the other. Most momentous results flow from this. The one hemisphere must be lighter than the other. This, indeed, is but another way of stating the discovery. The sphere of the moon may be regarded as made up of



MOON IN QUARTER.

a light half and a heavy one—the lighter being always turned towards the earth.

But how does this tell on the question of inhabitants? The application is very direct and startling. Supposing the sphere of the moon originally covered with water, and enveloped in an atmosphere, both water and air would flow to the heavier side, and leave the lighter side destitute of either, just as water and air would leave the summits of mountains, and gravitate toward the valleys.



RUGGED EDGE OF MOON.

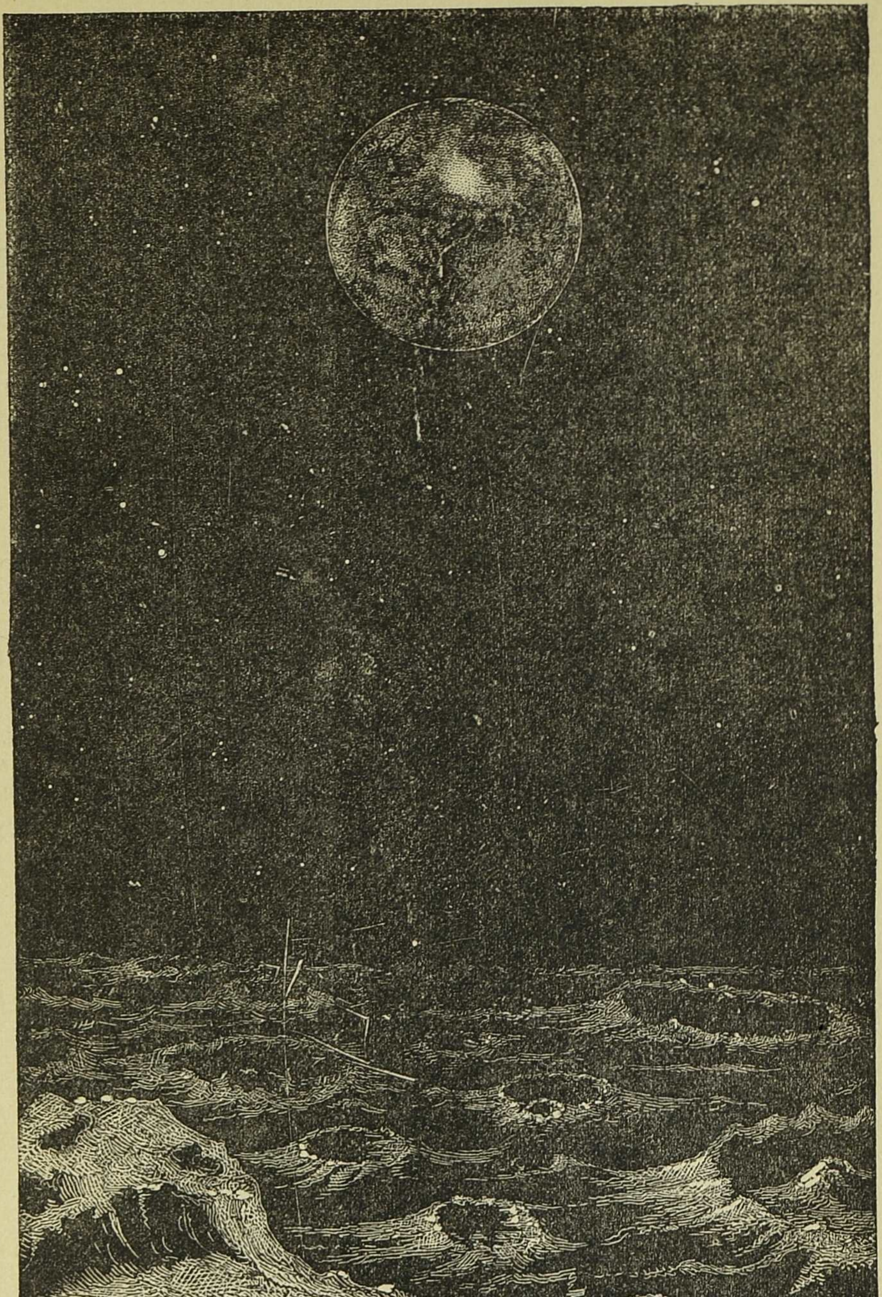
They seek the lowest level, or, in other words, the point least distant from the centre of gravity.

In the case of the moon, the side turned to us is virtually a mountain twenty-nine miles high, and the opposite side the corresponding valley. The conclusion is, that though the near hemisphere is a lifeless desert, having neitner water nor air to sustain life, the hidden hemisphere may have a teeming population, rejoicing in all the comforts and amenities of life. The imagination is set free to picture broad oceans, bearing on their bosom the commerce of this new world, rivers fertilising the valleys through which they flow, a luxuriant vegetation, and buildings of colossal size.

This, however, only increases the mystery, and the longing to see farther round the edge of the moon. If there was mystery before when life was not dreamt of, how much is that mystery increased, when we now know that there may be life—that there may be another world the counterpart of our own!

Everything on this side of the moon is fixed in the rigidity of death. No movement is observed indicating life or action.

How different would be the other side were we only permitted to obtain a glimpse! Its ever-changing atmosphere would be a source of continual interest; we could study its weather as easily as we could our own. And, if the atmosphere were not too dense, we could watch the progress of agriculture, and the growth of cities. If it is a world of strife, we could distinguish on the battle-field the colour of the uniforms of the opposing masses. All this could be accomplished by our present optical means; and, as our powers of vision increased, we could descend to the minuter details of life. We could readily conceive a code of signals by which telegraphic communication could be carried on. The moon, however, sternly with-



THE EARTH SEEN FROM THE MOON.

holds from us her great secret, and for ever turns from us her hidden hemisphere.

Granting that the other side of the moon is peopled, can our world be ever known to the inhabitants, seeing that only the lighter side is turned towards us ?

It is plain that the inhabitants, if they keep to their own side, can never get a glimpse of our earth. If there be an atmosphere, it is probable that it may extend a small way within the border of the opposite side, though in a rarefied form. We can then conceive the intrepid lunar inhabitants venturing as far as they can breathe within the barren hemisphere; just like adventurous travellers on our globe scaling lofty mountains to obtain an extended view of the landscape. What an astonishing spectacle must burst upon the view of the lunar tourist as soon as he fairly gets within the new hemisphere!

The traveller who has spent the night on the summit of the Rigi, to watch the rising of the sun over the snow-clad ranges of the Oberland Alps, feels rewarded for all his toil by the glorious spectacle. The visitor of the southern hemisphere, when he first beholds the southern cross, and the Magellanic clouds, experiences no ordinary delight at having a new portion of God's universe ushered into view. But these illustrations can but imperfectly enable us to realise the case of the lunar traveller, when he first beholds the earth.

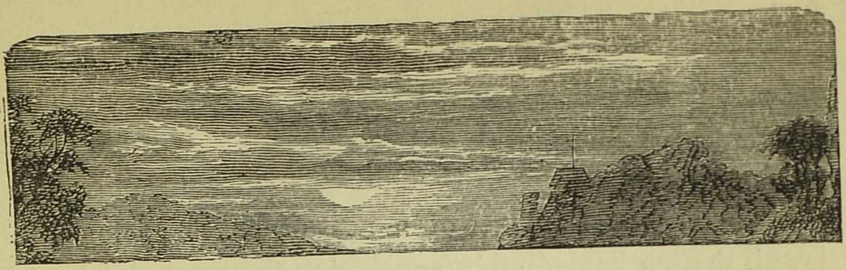
He will see an immense blue orb hung up, immovably fixed in the heavens. It will appear to him fourteen times larger than the moon appears to us. The sun will be seen, as in the other lunar hemisphere, to rise in one horizon, and in fourteen days set in the opposite, but the earth never moves. The stars at mid-day, as well as at midnight, will appear to pass behind its disc, while it maintains the same position. But though immovably fixed in the heavens, wondrous activities will be discovered.

It will exhibit in twenty-eight days all the phases of the moon—now a thin crescent, then a full orb. Its rapid rotation will also be a most notable object, for in so large an orb the twenty-four hour's period will be most marked. And then the blue atmosphere will be undergoing incessant changes. Belts, corresponding to the trade-winds, will be seen, and throughout the whole extent, the varying climates of the world be observable. Though objects on the surface of our earth will be but dimly descried, still our seas, continents, and mountain-ranges may be distinguished.

What a tale of wonder will the traveller have to tell, when, after his perilous adventures, he returns to the bosom of his family!

It is obvious that the results of M. Hausen furnish no positive evidence for the existence of lunar inhabitants. It is valuable to the advocate of a plurality of worlds, only in as far as it enables him to rebut the argument of his antagonist when he points to the moon as a proof that his speculations are only a dream. He can now maintain, that if we knew all, we should find that the moon is not destitute of life.

PLANETS AND COMETS.



PLANETS AND COMETS.

CHAPTER I.

PLANETS, THEIR ARCHITECTURE.

WE have already examined the architecture of the sun. We have pried into this central furnace, and have seen how curiously complicated is its arrangement. We have seen its surging flames, and the edges of its concentric strata, appearing like the bars of a mighty furnace. Our object is now to show, that the sun and planets belong to the same family, however diverse they appear to be.

We speak of the sun as if separated from the planets by a wide gulf, and as if belonging to a totally distinct class of bodies; but we shall find more points of resemblance than of difference.

The central position of the sun may seem to claim for it a distinctive character, but it is really only the last of a series. The link that terminates a chain is nothing more than a link. The innermost case of a mummy is only a mummy case, though painted with brighter hieroglyphics. The last of a nest of boxes enclosing a jewel, though immediately enveloping the precious object, is only one of the set. The centre of the solar system is the jewel, and the sun revolves around it just as the planets do. The only difference is, that its circle is the narrowest.

There is a type to which the planets and the sun equally belong.

The sun, no doubt, is an intense furnace, while the planets are in themselves dark bodies, but the structure may be still alike. If you saw only one furnace in action at an iron-work, you would not conclude that the others, which have been put out, belong to a quite different class of buildings. The hot-blast apparatus, the tuyeres, the furnace-bars, the well, and the slag before the furnace, would at once show the purpose of the erection, and prove that it had been used as a furnace. Though the sun is now the only body of the system in active operation as a furnace, there are evident indications that the planets were also at one time incandescent bodies.

Geology gives abundant proof of igneous action in our globe at a former period, and we have reason to believe that we now stand on a crust floating on a molten sea. When we look to the moon, we find innumerable extinct volcanoes, like so many furnaces in an iron district, put out by a general strike. The other planets do not allow us to see their minuter features, but analogy fairly leads to the conclusion that they were all, at one time, active furnaces.

The concentric envelopes of the sun are by no means a distinctive feature, or one that should separate it from the family of planets.

The rings of Saturn are only a special case of this concentricity—the ring being merely a flattened sphere. The envelopes of the sun are somewhat flattened, and Saturn's rings are only an extreme case. The spherical mop, when twirled, becomes a flat ring, so that the mere circumstance of motion explains the difference. The sun has, indeed, rings similar to those of Saturn.

The earth also affords an example of the concentric structure. In an eclipse of the moon, an inhabitant of that body would behold a spectacle similar to what is presented in a solar eclipse. He would see a faint corona, and, along the margin of the earth, he would see a copper-coloured stratum, with prominences like the rose-coloured shell of the sun, this stratum being the lower regions of the air loaded with moisture and clouds; and were he to see down through the crust of the earth, he would in all probability discover a concentric arrangement of the interior.

In the case of Jupiter and Saturn, it is obvious that we see only the outer shell, within which the bodies of the planets are concealed.

The disc of Jupiter presents very singular phenomena. There are indications of constant commotion, and the markings of the belts often present very perplexing forms, of which no account can be given. We only know that the visible disc is not a fixed and solid crust. It is like the visible envelope of the sun, which conceals the solid nucleus in its interior. The shadows of the satellites are seen as dark spots when they cross the disc of the planet, and the satellites themselves can also at the same time be detected by powerful telescopes.

Besides these, there are other spots of which no account can be given. They sometimes appear in clusters, as shown in our figure of the planet. They have a proper motion like the spots on the sun, and probably are due to the same general cause—the rotation of the body combined with the higher temperature of the equatorial regions. They will, therefore, correspond with the circular storms or cyclones in the atmosphere of our globe.

There is no evidence that we have ever as yet seen the kernel within the outer shell of Jupiter. The usual explanation of the dark belts of Jupiter is, that they are the more transparent parts of Jupiter's atmosphere, while the brighter parts are the region of clouds which reflect the light more abundantly.

In this hypothesis, we see the body of the planet down through the transparent region of dark belts, but it is more probable that, in the dark belts, we see only a part of an interior shell, and that the real body may lie far beneath. The dark belts would, in this way, correspond to the penumbra of the spots in the sun, which is only

GALILEO DISCOVERING SATURN.

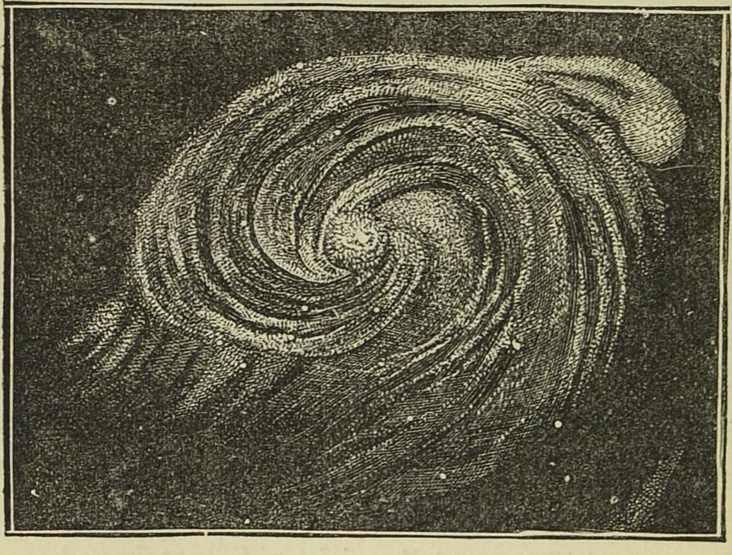
an uncovered part of the stratum immediately under the luminous envelope.

Jupiter is by far the largest of the planets, and yet it may have only a small solid nucleus. Though, taken as a whole, Jupiter is not heavier than a sphere of water of the same size, we can readily suppose the real body of the planet to be of much heavier matter. It may be compared to a bullet of lead forming the core of a sphere of cork.

Dr. Whewell's argument, then, is of no force, when he holds that Jupiter can only be the abode of molluscs, and other lower forms of life suited to a watery abode. Even though the body of Jupiter had only the density of water, it would not at all be necessary to assume that it must necessarily be fluid, for we know of many solid substances as light as water. But there is no necessity for holding that its density is only that of water. The Jovial ball may be as dense as that of the earth, and may afford to the teeming inhabitants as sure a footing as our roads and streets.

How astonishing must the sight of Saturn have been to Galileo when he first descried its strange form! It was, however, long before the character of the monstrosity was understood. A telescopic power as small as that which Galileo used is sufficient to convince any one at the present day that there is a ring round the body of the planet; yet Galileo did not see a ring. He called the parts of the ring, projecting on each side of the planet, *ansæ*, as they appeared like the two handles of an antique vase. We may see nothing more at the present day, and yet every schoolboy would at once know that they are only parts of a ring seen obliquely, and would maintain that he was indebted only to his sight.

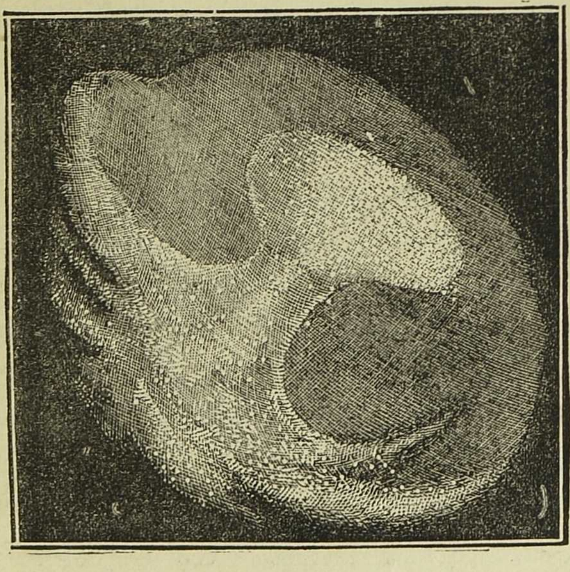
This is only one illustration of a thousand, that, for what we see around us, we are as much indebted to the intellect as to the eye.



SPIRAL NEBULA.

The organ of sense gives only skeleton forms, which the intellect and imagination fill up. When showing objects through a microscope to one unaccustomed to the use of it, you are sometimes astonished that he does not see what is so obvious to yourself; but the mere objective nucleus is unmeaning, unless the previously trained mind can clothe it with significance.

It is sometimes matter of surprise that men, living amongst the beautiful and interesting scenes of nature, should be totally uninfluenced by them; but the truth is, the objects that interest us may not be really seen by them. For thousands of years, the spots on the sun and the zodiacal light must have impressed an image on the human retina, and yet we have no evidence that they



DUMB-BELL NEBULA.

were ever really observed till modern times. Another case, still more in point, is the obscure and innermost ring of Saturn. It must have been often pictured on the retina of observers, and yet it was not really observed till a few years ago. Some, indeed, suppose that it must have been developed in recent times, but the ordinary laws of observation furnish us with a sufficient explanation.

When the rings of Saturn were fairly descried, the structure of the planet must have appeared still more marvellous. How contrary to all preconceived notions of the stars!

But no sooner is the human mind struck with astonishment, than it seeks to divest the wondrous object of its singularity. There is an instinct that makes us seek for points of singularity. The idea of one presiding intelligence leads us to the conviction that, however strange the phenomenon may be, it must be in harmony with the other works of God, and this, not merely in reference to adaptation, but to style. Every architect must conform to certain structural rules, without which he cannot erect any edifice; and we find design and adaptation in every building. But, over and above this, there is the undefinable idea of style, and we expect, amidst all diversity, to detect the manner of the man of genius. Genius confers a unity on works of the most diverse structure and design. We expect to find this unity in the style of God's works, apart from mere adaptation.

But is it possible to detect a unity of structure in the solar system, when we have the singular and startling exception of Saturn? Is it really in gear with the other parts of the solar system, as far as style is concerned? It is to this interesting point we would now address ourselves.

PLANETS AND COMETS.

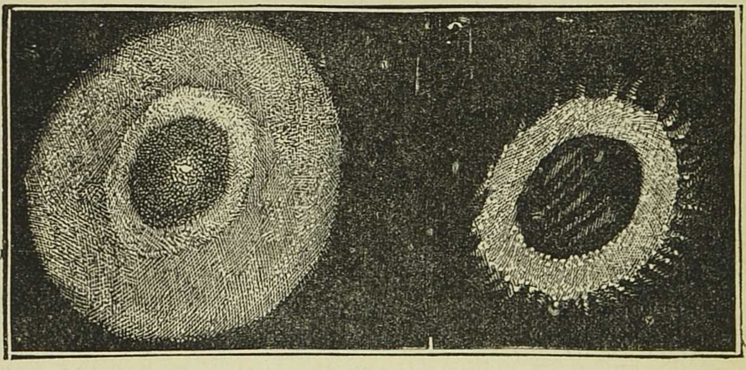
CHAPTER II.

PLANETS, THEIR ARCHITECTURE (*continued*).

IS there, then, apart from all theories of development, a general style of architecture in the solar system, to which the structure of Saturn conforms?

We think there is, and that there is a traceable gradation of distinctive characters through all the planets. The fish is the lowest form of the vertebrate type of animals, and the scale upwards to man is marked by the differentiation of limbs. They are undeveloped in the fish, and they rise, through innumerable steps, to perfection in the human species. Comparing the solar with the vertebrate system, the moon, with its naked ball, may represent the undeveloped form of the fish, and Saturn the highest form of vertebrate animals.

When we speak of the typical perfection of a planet, we do not at all refer to its adaptation to life. We mean merely the degree in which the distinguishing characteristics of a general style are exhibited. The grand characteristic is the concentricity of structure, which we before traced in the sun. In the sun, we have seen that there are successive envelopes or shells around the core. Three of these were recognised before the last total eclipse, and the phenomena of the eclipse have clearly established, what was before surmised, another envelope



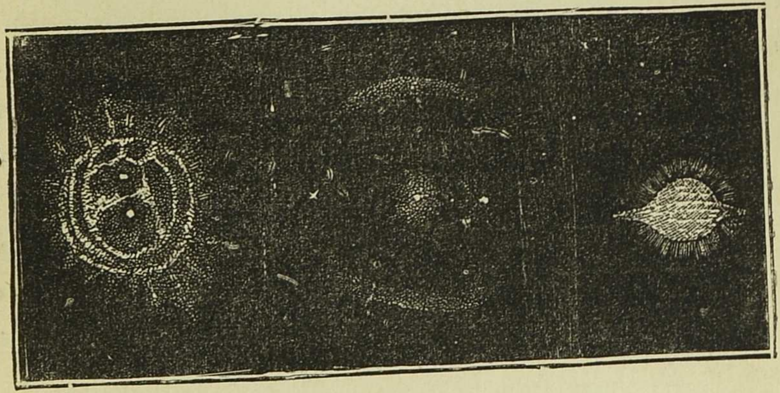
RINGED NEBULÆ.

of rose-coloured matter; and, extending beyond this stratum, there is the corona, which is, most probably, the atmosphere in which all the others are suspended, like strata of clouds at different heights of our atmosphere.

We have reason to believe that Saturn, as well as Jupiter, is constructed on a similar concentric plan, and that his belts are indications of an internal envelope. But does the similiarity between the sun and Saturn cease here? By no means; the grand peculiarity of Saturn has its analogue in the sun. Saturn has a series of concentric rings, but so has the sun. Where are they? it will be asked. We have no hesitation in answering that the zone of asteroids between Mars and Jupiter, as well as the zodiacal light, are fairly analogous.

Take the bright rings of Saturn, and let us compare them with the zone of asteroids.

These rings have all the appearance of being solid



VARIOUS NEBULÆ.

bodies when you take only a cursory glance, but on more minute inspection, proofs leading to an opposite conclusion will be found. There is only one large dark division, but a smaller one at both ends of the *ansæ*, dividing the outer ring into two, is sometimes seen. The views, however, are so capricious, that the observer is naturally led to the conclusion that there are changes going on in the constitution of the rings.

Again, some have observed a structure in the whole breadth of the rings, similar in appearance to a flat coil of rope or the ribbed texture of corduroy, rendering it probable that the rings are composed of small bodies closely packed and arranged like concentric strings of beads laid flat on a table. The bodies, on this hypothesis, have no rigid connection, and move in independent orbits. They are, however, so closely packed together, that they appear as one body. The zone of the asteroids quite corresponds to this. It is probable, from the rate of discovery, that there are thousands upon thousands within the circumscribed zone. To an eye properly situated, and at a sufficient distance, this zone would appear as a faint ring. If more compressed, they would be bright, like the rings of Saturn.

These asteroids are probably of every size. Some are large as a kingdom or a county; others are miniature worlds, of the size of Arthur's Seat; and some may dwindle down to the magnitude of a cannon-ball. We may suppose them so arranged as to leave gaps corresponding to the divisions of Saturn's rings.

Again, the obscure ring of Saturn may be compared to the zodiacal light.

It will be seen from our figure of the planet that the recently discovered ring is transparent, as the limb of the disc is seen through it. It is most probably composed of some discrete substance, like dust, as it does not comport itself like a gaseous body. This is probably also the constitution of the zodiacal light, which is another ring or zone nearer the sun, the boundaries of which are not well

DOUBLE SPIRAL NEBULA.

defined. It is shaped somewhat like a quoit. The sun being in the middle of the central hole, we see only the edge of it when it appears to rise as a long cone from the horizon. It is best seen in February and March above the part of the horizon where the sun has set.

The generally received opinion is, that it is composed of meteoric bodies; and some hold that it may extend beyond the orbit of the earth, so that we pass through it twice a year. The meteoric bodies become incandescent when they meet our atmosphere, and the two annual periods of meteoric showers are accounted for by the intersection of the earth's orbit at two opposite points. To an eye at a great distance, the sun would appear as if surrounded by two faint rings, with a wide, dark space between, while the outer ring, or that of the asteroids, would likely be subdivided by smaller dark lines.

The calculations of Leverrier, and the discovery of Lescarbault, render it very probable that there is a zone of planets or asteroids within the orbit of Mercury, so as to form a third faint ring encircling the sun. Leverrier has also shown that the perturbation of Mars indicates the existence of a zone of meteorites whose diameter is nearly equal to that of the orbit of the earth. Such a zone would most naturally explain the phenomena of meteorites and their periodicity.

The next marked example of the concentric structure is furnished by comets. In their case, we see the very formation of the strata or envelopes. They grow before our eyes, and afford a type of the structure of the more solid bodies of the solar system.

Most of the planets are so remote from us, or so near the sun, that we cannot speak with certainty of their envelopes. As far as our knowledge extends, the moon stands lowest, as she has no shell of any kind surrounding the solid ball. Mars probably comes next. We can at all times see the fixed features of his surface, and nothing like clouds has been detected, though there is evidence for an atmosphere. Next comes the earth with her far-extending atmosphere and her stratum of clouds. Jupiter ranks next in order; and lastly, Saturn, the most complete example of concentricity of structure.

In the case of the moon, taken as a whole, we do not indeed find a concentric structure; but almost the whole surface is covered with volcanic craters, the principal feature of which is concentricity. The cone in the centre, the encircling cavity, the rim with its successive terraces, all combine to carry out the planetary ideal.

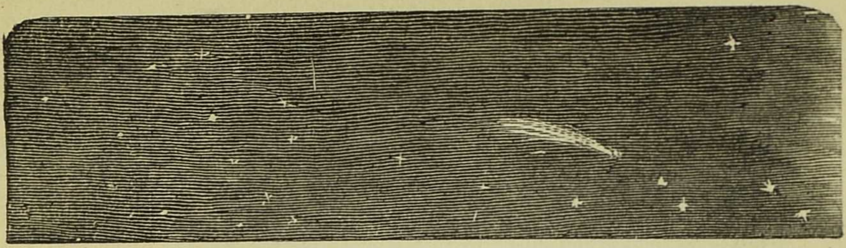
When we descend from the cosmical type of the planetary system to the lowest forms of organization, we discover the same concentric feature. The section of a tree exhibits the concentric rings of the planet. The flower, with its pistil in the centre, and its encircling anthers, petals, and calyx, shadows forth the all-pervading plan, alike stamped on the orb of heaven and the lily of the valley.

When we range beyond the solar system, and extend our view to other suns and systems, we shall find diversity, but nothing to destroy the unity of plan, or shake our belief that all is the product of one divine idea. When we fathom the depths of space, we discover similar forms.

We behold the masses of stars grouped into rings, and sometimes exhibiting traces of stratification.

But there is a higher form, into which increased telescopic power is fast resolving other forms, viz. the spiral. The planetary type is the concentric arrangement of the section of a tree. The streams of stars constituting nebulæ are coiled up like the mainspring of a watch, or wheeling round to the centre of a vortex. The spiral is the archetype, and comprehends the concentric circles of the planetary systems. We may not be able to trace the transition, but no one can compare the rings of Saturn with the spiral of a nebulæ, without feeling that they are allied forms, though the link may not yet be detected.

Our dwelling-place is in a small corner of a vast edifice, and, roam where we may, we shall find proofs that the plan is the same throughout. The cathedral of Cologne has had many architects employed upon it, but there is in every part evidence of one presiding mind. The successors of the original designer have only striven to carry out his ideas. There is one pervading style in the architecture of the heavens, and though subordinate agencies have been employed to carry it out, they do not in the least prevent us from recognising the hand of the Original Designer.



PLANETS AND COMETS.

CHAPTER III.

COMETS.

IN ancient history several very remarkable comets stand recorded. One is mentioned by the Greek philosopher, Aristotle, in 371 B.C., with a tail extending over a third part of the sky.

Many great comets are recorded at even more ancient dates in the Chinese annals; for that strange people kept an official record of all the remarkable stars, meteors, and other celestial appearances for more than a thousand years before the Christian era, and, what is stranger still, that record has been handed down to us, and seems dependable.

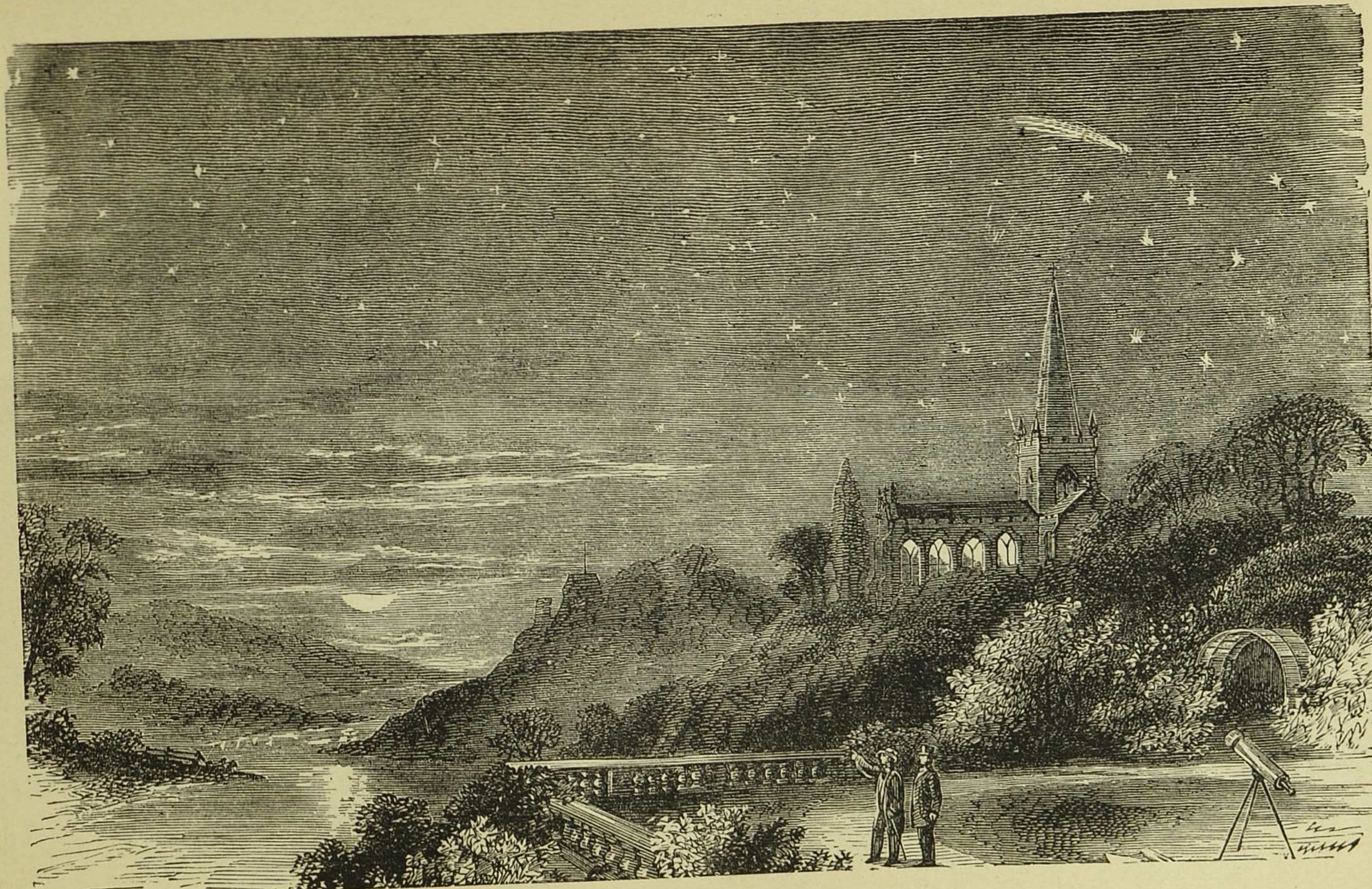
A great comet was seen close to the sun sixty-two years before Christ, during a total eclipse; and one which appeared in the year 43 B.C., soon after the murder of Julius Cæsar at Rome, was seen by all the assembled people in full daylight. Such a thing, though very uncommon, is by no means singular; it has happened several times, and in one even quite recently; for the great comet of 1843 was seen at noonday quite close to the sun, both in Nova Scotia and at Madrid, and before sunset at the Cape of Good Hope.

Of course it is only the brightest part or the head of a comet that can ever be so seen; the faint light of the tail has no chance of contending against broad daylight.

Before the invention of telescopes, the appearance of a comet was a rare occurrence, because only a small proportion of them can ever be seen by the naked eye; and of these again only a small portion are considerable enough to attract much attention. Since that discovery it has been ascertained that they are very numerous; hardly a year passes without *one*, and very often two or three, and in one year, 1846, no less than eight were observed.

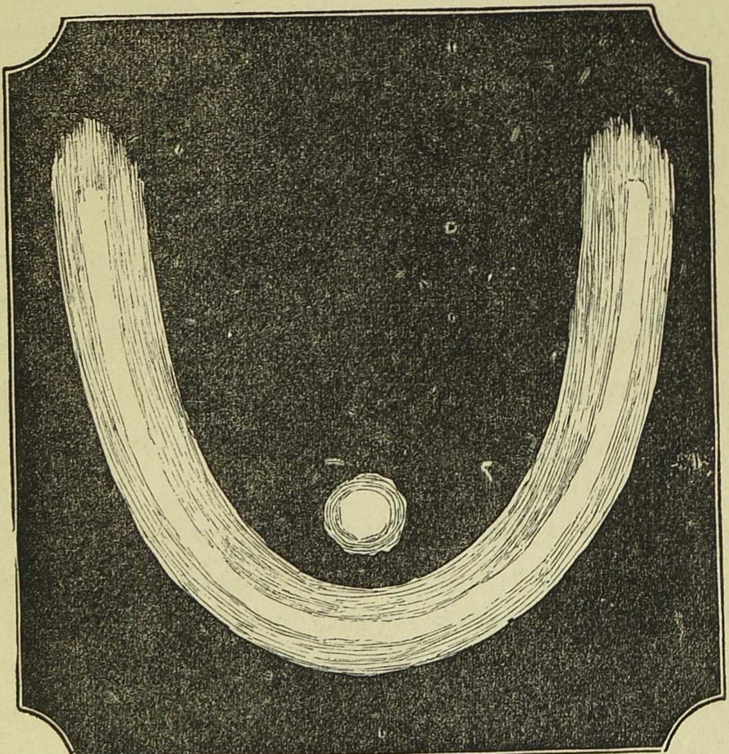
Taking only two a year on an average as visible if looked for in a telescope, and considering that at least as many must occur in such situations that we could not expect to see them, in the six thousand years of recorded history there must have been between twenty and thirty thousand comets, great and small.

A *great* comet, however, hardly occurs on an average oftener than once in fifteen or twenty years, or even yet more rarely; though, as sometimes happens in matters of pure accident and in the course of chances, it is not



MIDNIGHT SKY—MOON, STARS, AND COMET.

very unfrequent (and we have lately seen it remarkably exemplified) for two, or even three, very great comets to follow each other in rapid succession. Thus the great comet of 1680 was followed in 1682 by another very conspicuous one, of which we shall have more to say.



HEAD AND NUCLEUS OF COMET, 1811.

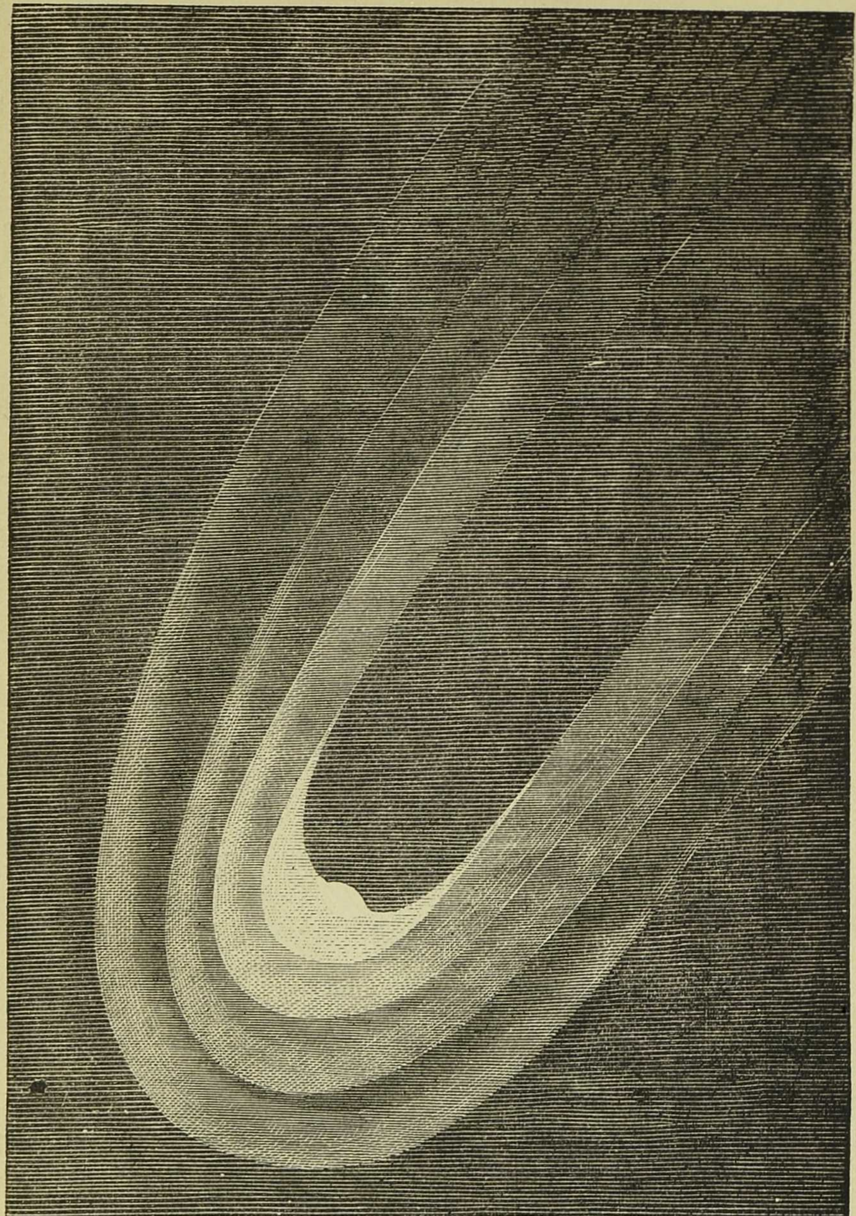
When a comet is first discovered in a telescope, it is, for the most part, seen only as a small, faint, round or oval patch of foggy or, as it is called, *nebulous* light, somewhat brighter in the middle.

By degrees it grows larger and brighter, and, at the same time, more oval, and at length begins to throw out a "tail," that is to say, a streak of light extending always in a direction *from* the sun, or in the continuation of a line supposed to be drawn from the place of the sun, below the horizon, to the head of the comet above it.

As time goes on, night after night the tail grows longer and brighter, and the "head," or nebulous mass from which the tail seems to spring, also increases, and within it begins to be seen what is called a "nucleus," or kernel —a sort of rounded, misty lump of light dying off rapidly into a haziness called the *coma*, or "hair." Within this, but often a good deal out of the centre, there is seen, with a good telescope and a high magnifying power, a very small spark or pellet of light, which may or may not be the solid body of the comet, and which is the real nucleus.

All the while the comet is getting every evening nearer and nearer to the place of the sun, and is therefore seen for a shorter time after sunset, or before sunrise, as the case may be (for quite as many comets are seen in the morning before sunrise, as in the evening after sunset). At last it approaches so near the sun as to rise or set very nearly at the same time, and so ceases to be seen except it should be so very bright and so great a comet as to be visible in presence of the sun.

When this has taken place, however, the comet is by no means to be considered as dead and buried. After a time it reappears, having passed by the sun, or perhaps



COMMON FORM OF COMET.

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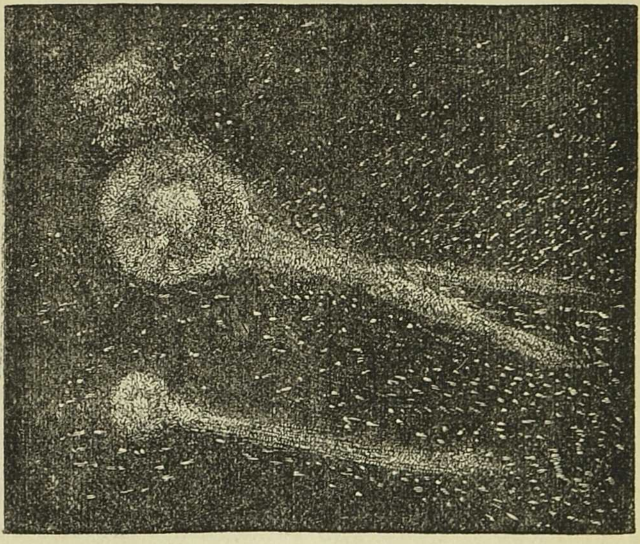
before or behind it, and got so far away on the other side as to rise before the sun, or set after him. If it first appeared after sunset in the west, it will now reappear in the east before sunrise. And, what is very remarkable, its shape and size are usually totally different after its reappearance from what they were before its disappearance. Some indeed never reappear at all. The path they pursue carries them into situations where they could not be seen by the same spectators who saw them before.

Others—like those which appeared in 1853 and 1861—without altogether disappearing as if swallowed up by the sun, after attaining a certain maximum or climax of splendour and size, die away, and, at the same time, run southward, and are seen, as that of 1858 was (on the 11th of October for the first time), in the southern hemisphere, the faded remnants of a brighter and more glorious existence, of which we here witnessed the grandest display. And, on the other hand, we here receive, as it were, many comets from the southern sky whose greatest display the inhabitants of the southern parts of the earth only have witnessed.

It also may often happen that a comet, which before its disappearance in the sun's rays was but a feeble and insignificant object, reappears magnified and glorified, throwing out an immense tail, and exhibiting every symptom of violent excitement, as if set on fire by a near approach to the source of light and heat. Such was the case with the great comet of 1680 and that of 1843;

both of which, as I shall take occasion to explain, really did approach extremely near to the body of the sun, and must have undergone a very violent heat.

Other comets, furnished with beautiful and conspicuous tails before their immersion in the sun's rays, at their reappearance are seen stripped of that appendage, and altogether so very different that, but for a knowledge of



DOUBLE COMET.

their courses, it would be quite impossible to identify them as the same bodies. This was the case with the beautiful comet of 1835-6, one of the most remarkable comets in history.

Some, on the other hand, which have escaped notice altogether in their approach to the sun, burst upon us at once in the plenitude of their splendour, quite unexpectedly, as did that of the year 1861.

I come now to speak of the paths described by comets in the sky.

Now, we all know that the sun, moon, and planets keep to certain high roads, like beaten tracks in the sky, from which they never deviate beyond definite and narrow limits assignable by calculation.

With comets it is far otherwise. They are wild wanderers, and care nothing for beaten tracks. A comet is just as likely to appear in any one region of the starry heavens as in any other. They are no respecters of boundaries. The first time a comet is seen, no one can tell where it may next day be. The second observation still leaves a great uncertainty as to its future course. The third nails it. After three good observations, carefully made, of its place, we can thenceforth tell where it will go.

Meanwhile, such is the variety of which their paths are susceptible, that for a very long time their movements were considered to be altogether capricious and unaccountable—creatures of chance, governed by no laws. *Now*, the case is different.

Comets are wild wanderers; yet the sun controls the movements of them, and by the very same force acting according to the very same law which retains the planets in their paths—that marvellous law of gravitation.

The same power which draws a stone thrown from the hand back to the earth, which keeps the moon from flying off and holds her to us as a companion, which keeps the planets in their well-beaten tracks about the sun, controls all the wanderings of the comet.

Planets are tame and gentle things for gravitation to deal with; a little tightening of the rein here, and a little relaxation there, as they career round and round, suffices to keep them and to guide them in their graceful and smooth evolutions. We belong to a planet, and we can realise this law.

But here is a stranger from afar—from out beyond the extremest limits of our system—dashing in, scorning all their conventions, cutting across all planet orbits, and rushing like some wild infuriated thing close up to the central sun, and turning short round it in a sharp and violent curve, and with a speed, in some cases of 1,200,000 miles an hour at the turning point, and then going off at a new and ever-changing pace. But, in its wildest gallop and its easiest walk alike, it is curbed by the guidance of a firm and steady leading-rein held by a powerful hand.

The most magnificent ever seen was the comet which appeared from November, 1680, to March, 1681. In its approach to the sun it was not very bright, but began to throw out a tail when about as far from the sun as the earth. It passed its perihelion on December 8th, and, when nearest, it was only *one-sixth* part of the sun's diameter from his surface, and at that moment had the astonishing speed of 1,200,000 miles an hour.

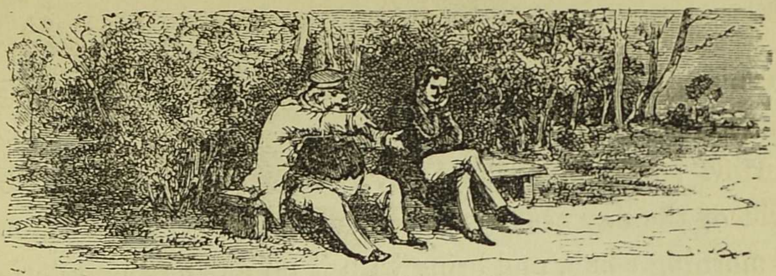
Now, observe one thing. The distance from the sun's centre was about the one hundred and sixtieth part of *our* distance from it. All the heat we enjoy on this earth comes from the sun. Imagine the heat we should have to endure if the sun were to approach us or we the sun to the one hundred and sixtieth part of its present distance! It would not be merely as if one hundred and sixty suns were shining on us all at once, but *one hundred and sixty times one hundred and sixty*. Now that is 25,600.

Only imagine a glare 25,600 times fiercer than the sun —not the sun as felt in England, but in the tropics, at the equator, and at noonday. And again only conceive, not only a heat, but also a light 25,600 times more glaring than the glare of such a noonday! In such a heat iron, rock, and every solid substance we know of would run like water and boil away in smoke and vapour.

No wonder that at such a time the comet gave evidence of violent excitement. It had come from the cold region outside the planetary system, torpid and ice-bound. When arrived in our temperate region, it began to show signs of internal activity: the head began to develop and the tail to elongate, till the comet was for a time lost sight of in the intense splendours of nearness to the sun. No human eye beheld the wondrous spectacle it must have offered on the 8th of December. It was as above described. Four days afterwards, however, it was seen, and its tail had already lengthened to an extent of about ninety millions of miles.

All this is very mysterious. We shall never, perhaps, quite understand it; but the mystery will be, at all events, a little diminished when we come to understand some of the things which are seen to be going on in the heads of comets under the excitement of the sun's action, and when calming and quieting down afterwards.

LIGHT.



LIGHT.

CHAPTER I.

WHAT IS IT?

THE peculiar communication between us and the surrounding world in which we see is called light.

What is light? Many will be ready to think light at least a very tame and feeble thing. Why so? Because it is noiseless. Most people think much of noise. An earthquake is to them a much more vigorous and effective agency than a sunbeam. Hear how it comes thundering through the solid foundations of nature! It rocks a whole continent. The noblest works of man—cities, monuments, and temples—are in a moment levelled to the ground, or swallowed down the opening gulfs of fire.

Just so. But what says all that? The light of every morning, the soft, genial, and silent light, is an agent many times more powerful.

How so? you perhaps say. How so! Why, let the light of the day cease and return no more; let the hour of morning come, and bring with it no dawn; the outcries of a horror-stricken world would fill the air. The beasts would go wild and frantic at the loss of the sun; the vegetable growths turn pale and die. A chill would creep on, and frosty winds begin to howl across the freezing earth. Colder and yet colder would be the night. The vital blood of all creatures would at length stop congealed. Down would go the frost toward the earth's centre. The heart of the sea would be frozen; nay, the earthquakes themselves would be frozen in under their fiery caverns. The very globe itself, too, and all the fellow-planets that had lost their sun, would become mere balls of ice, swinging silent in the darkness.

Such, says a true and eloquent writer, is the light which revisits us in the silence of the morning. It makes no shock or scar. It would not wake an infant in its cradle. And yet it perpetually new-creates the world, rescuing it each morning as a prey from night and chaos. *That* is light.

But we are not satisfied with this knowledge of magnificence, of goodness, and power. So with our interest in the question only deepened by it, again we ask, What is light? The answer will be more clear if we proceed to it step by step.

So to begin. The fact that we see is proof that there is a communication of *some sort* between the eye and the thing seen; and the fact that we cannot see in the dark is proof that such communication is *not* by the mere power of the eye.

Now remember this, and look at another fact—a strange-sounding fact, but a fact notwithstanding—Light, though the cause of vision, is itself invisible!

But you say, "Oh, I'm sure I have seen a sunbeam." It is true that a sunbeam is said to be seen when it traverses a dark room through a hole in the shutter, or when in a partially clouded sky luminous bands or rays are observed, as if darted, through openings in the clouds. But the thing seen to man in such cases is not the light, but the illuminated portion of darkness or shade, as when in a thick fog the bull's-eye of a lanthorn seems to throw out a broad, diverging, luminous cone, consisting in reality of the whole illuminated portion of the fog.

When you put your hand on two objects separated by a short distance, you may be said to *feel the space* between them; but you do not, you only feel the objects, and you know from them that there *is* a space. A sunbeam is an illuminated *space*, which you know by the dark or shade on its sides.

Light is invisible, yet it makes things visible. Look at the moon. The moon is seen in virtue of the sun's light. It is a reflector sending down to us rays thrown upon it. Where the moon is not we see nothing, though rays of sunlight are on all sides.

And so of the planets. When we look out on a dark night, though we are sure that all space is continually being crossed in every direction by the lines of light, along all which it is active, and in particular that all the dark space immediately around us is, so to speak, flooded with the sun's light, we yet perceive only darkness, except where the lines of light fall upon a planet. So we see this much: that light is something invisible, but something which *makes* visible.

What, then, is this invisible thing called light? The answer is wonderful enough. Light is vibration—the vibration of a something which fills all space, which something, clever men call Ether. Light is the motion of ether. That motion of this ether is termed "wave-motion."

Yes, light is motion.

Now, mark the fact that there are different kinds of motion. There are, at least, motions which are *felt*, motions which are *heard*, and motions which are *seen*; and these motions are again divided into two kinds—motion which *pushes* something out of its place, and motion which merely *passes through*, and is called vibration.

There is motion which, like the motion of *air*, we feel. The motion called wind appeals to our sense of touch. This motion pushes the air from one place to another. That motion is not called vibration, so is not like the motion called light.

Then there is a motion which, like that of a note in *music*, may be heard. By music the air is put in motion; but it is not pushed from place to place. When listening to an organ, we do not feel a breeze issuing from the instrument. Yet there is motion, a kind of wave-motion, an onward movement which passes through the medium, and does not push it out of its place. Now, don't get tired of this path to a glorious knowledge.

To get a clear meaning of this stand-still sort of motion, fasten a long cord from place to place, and make it tight. Then catch it with the finger. The cord will be set in motion, a wave will run along from end to end, but the ends of the string will remain exactly in the place you put them. Now imagine one end of the string to be the sun, and the other end the eye, and you will see at once the meaning of the wave-like motion of a ray of light. A ray of light does not shoot out of the sun, but trembles down through space from it in lines somewhat like the imaginary cord.

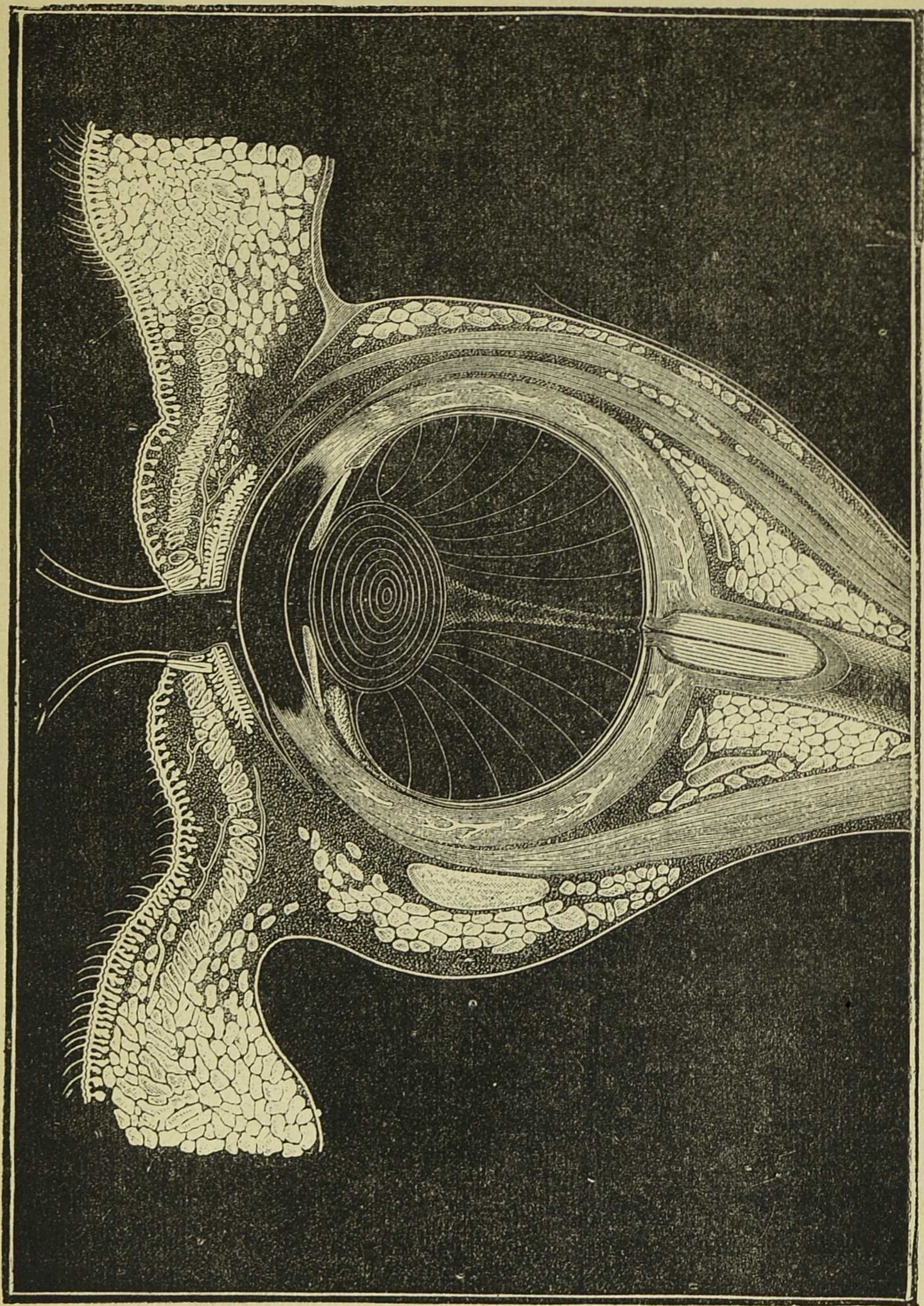
Now tighten your cord, and again set it in motion by a catch of the finger, and you will observe that the waves of motion along the string are quicker and shorter than they were; there are more of them in a second, and more of them at any one time between the two ends of the string; and so, as there are more vibrations in the same space, you see that all vibrations are not of equal length. So is it in the rays of light; the wave-like motion of different rays of light differ very much in their length and in their quickness.

And now for the final fact in this story of light-making waves, and what is most marvellous of all—

what we call colour depends on the length and quickness of these waves. If quick and small, the effect on the eye is one colour; if slower and larger, the effect on the eye is another colour. And men have measured these waves, and counted them, and know just how many make this and how many make that colour. If the ether waves are sixty thousand to an inch, the colour which they will carry into the eye will be violet.

Not only have men measured how many waves there are in the inch, they have also reckoned how many there are in a second. For red light it is four hundred and eighty-two million millions in a second; while for violet light it is no less than seven hundred and seven million millions a second! The number of vibrations which cause yellow is mid-way between these extremes.

What greater wonder can be expressed than to say that during every second the eye is looking at a violet flower or mauve ribbon, that on the delicate retina there break seven hundred and seven million millions of waves of there! Conceive the number! Suppose that there were three million people in London capable of counting one hundred every minute. Set this vast multitude to count on twelve hours every day, and let them keep on for nearly ten years; then let them add together all the figures counted, and when they had done they would find that they had counted seven hundred and seven million millions. That is, after all their labours they would have told the number of the vibrations which, being given in *one second*, make to us the colour violet.



THE EYE, THE ORGAN OF LIGHT.

X

How wonderfully we are made! What a miracle of nature is the retina of the eye! So delicately constructed is it, that it can detect the difference in these countless, inconceivable vibrations. The optic nerve, too, transmits them all faithfully to the brain. What fact is more sublime—more awful!

Some persons cannot detect these differences between the vibrations. Such persons are called colour-blind; they can see forms of things, but the proper number of vibrations not being registered, the right colour is not perceived.

Light, then, is a traveller—a wave-traveller from place to place. Now all ordinary travellers take time—a letter by post, a charge from a gun, a wave on a pond, a sound from crashing thunder. The letter we received this morning was posted yesterday—the gun flashed some seconds before we heard the ring of the bullet against the mark—the lightning had ceased to be visible till you had counted five before you heard the thunder crash. All ordinary travellers take time.

Does this traveller take time too? Most assuredly. He is like all his fellow-pilgrims. He takes time.

How long, then, are vibrations in travelling? The vibrations move at the prodigious rate of a hundred and eighty-five thousand miles a second from their origin in the sun to the human eye. But swift as this motion is, a wave of light issuing from the sun is eight minutes on its journey before it reaches the earth, for it has the prodigious distance of ninety-five millions of miles to come.

Ninety-five million miles! The figure is past thinking. If you were to undertake to count the miles the sun is distant as fast as you could, say at the rate of ten thousand an hour for ten hours a day, you would have to count for nine hundred days, or for nearly three years, before you would have finished your counting. But far as is the distance, it is soon got over, for light is a swift as well as a far traveller. The distance to the sun one of our express trains could only travel—travelling day and night—in two hundred and seventy years. But it is passed through by a beam of light in eight minutes!

But how do people know this? The way to the knowledge is almost as wonderful as the knowledge itself. So we will answer the question. Everybody knows that Jupiter has four moons. These four moons circle round the planet, and therefore must at times appear to us to pass on its other side, and so become eclipsed. Now on this account Jupiter may be made into a very good night-clock to people at sea; the four moons are like the figures and moving hands on a clock-face. If these sea-going people only take a book with them that tells what time these moons will become eclipsed, they can know when they are eclipsed that it is just that time of night; and the beauty of this Jupiter clock is, that it goes without winding up, and keeps exact time. Suppose astronomers have reckoned and put down in the book that to-night one of the moons will pass behind the planet at twenty minutes to ten o'clock, the captain of a vessel turns his telescope upwards, watches that moon, observes the exact moment that the little bright spot is lost behind the planet, and then he knows that by Greenwich time it is just twenty minutes to ten o'clock.

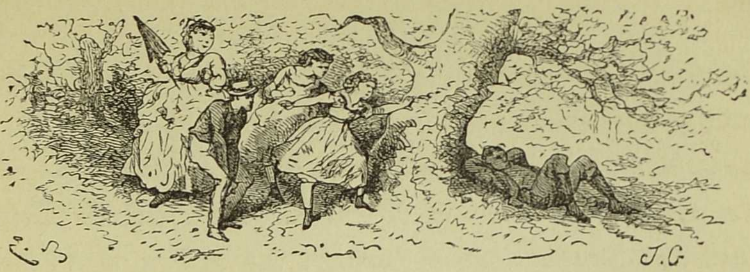
Everybody knows that this same four-mooned planet moves round the sun in its orbit, as does our world, but not at the same apparent pace, so that at one time we are on the same side of the sun, and at others on opposite sides.

Well, in 1676, an astronomer noticed that the moons of Jupiter did not appear always to act alike. He found out that when Jupiter was on the same side of the sun as the earth, and therefore nearest the earth, his moons went behind him always a little too soon, and when he was on the opposite side of the sun from the earth, and therefore the farthest from the earth, they went behind always a little too late. There was a difference of no less than sixteen minutes between the two cases.

Then arose the question, What made this difference ? Did light take time to travel ? And there was only one answer.

We saw the eclipses after they took place, and the light took sixteen minutes more time in travelling from the points where Jupiter was at the point farthest from us than it did in travelling from the point where he was at his nearest to us—in other words, that between the two points light takes sixteen minutes to travel. Now, as it was believed that that distance was one hundred and eighty-six millions, and as it took sixteen minutes to cross it, it was reckoned that its rate of travel must be one hundred and ninety-two thousand five hundred miles a second. This rate was not quite correct, but the true and grand discovery was that light took time to travel.

Modern experiments show that this statement of the speed of light erred in being somewhat too great. In these experiments, instead of measuring by the distance of Jupiter, it has been measured by machinery beautifully suited to the purpose. As the ultimate result of these experiments, the velocity of light is found to be one hundred and eighty-five thousand one hundred and seventy-two miles per second.



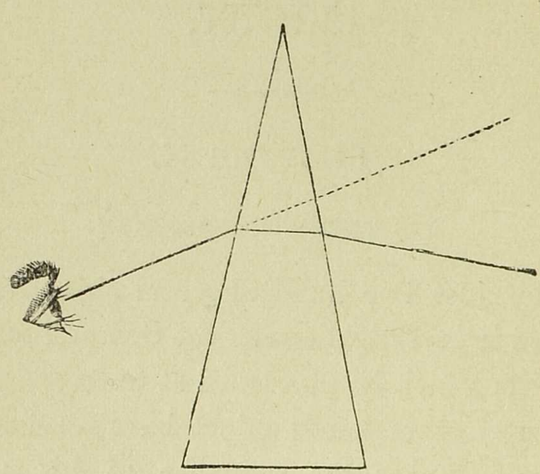
LIGHT.

CHAPTER II.

ITS PRISMATIC SPECTRUM.

IT is now just two hundred years since Newton was engaged in investigations on the Composition of Light. The prism which he purchased at Stourbridge fair, and which in any other hands might have remained a mere toy, became, under the guidance of his penetrating sagacity, an instrument of profound research. Holding it in a horizontal position, with one of its faces uppermost, near a round hole in the shutter, through which a beam of light was admitted into a darkened room, he found that when this beam fell on one of the sloping sides of the prism, it passed out from the other side in a very much changed position.

As to the immediate effect of the prism, he found that in its first passage from air into glass it was refracted, or bent from its previously oblique course into the horizontal; and then, having traversed the thickness of the prism, it was again refracted, on emerging from the glass into air, so as to slope upwards. But still further he found that having passed through the prism, when it fell upon the opposite wall, or on a screen placed in the middle of the room, it made—not a round spot of white light, such as it would have formed if it had not passed

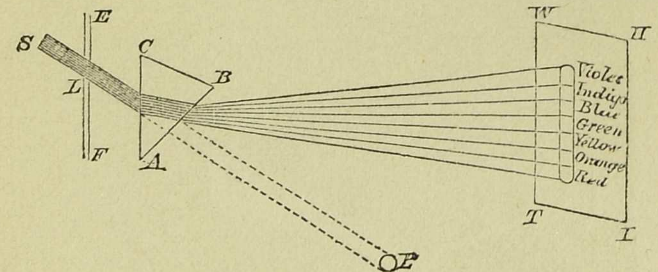


EFFECT OF PRISM ON RAY OF LIGHT.

through the prism,—but a vertical band about five times as long as it was broad, showing all the colours of the rainbow in regular succession, from red at the bottom to violet at the top.

Thus it was discovered, first, that the white or colourless light of the sun may be regarded as compounded of these differently-coloured rays, which, when separated from each other by the prism, in virtue of their different refrangibilities form the succession of "prismatic colours" in the spectrum.

And secondly, that the rays which form the "Solar Spectrum," as Newton termed it, in the degree in which they are respectively bent out of their direct course by their passage through the prism, *differ in refrangibility*, that is, in their power to be turned out of their natural straight line, that is, the violet rays being the *most* refrangible, and the red the *least* refrangible, the violet is found



COLOURS OF SPECTRUM.

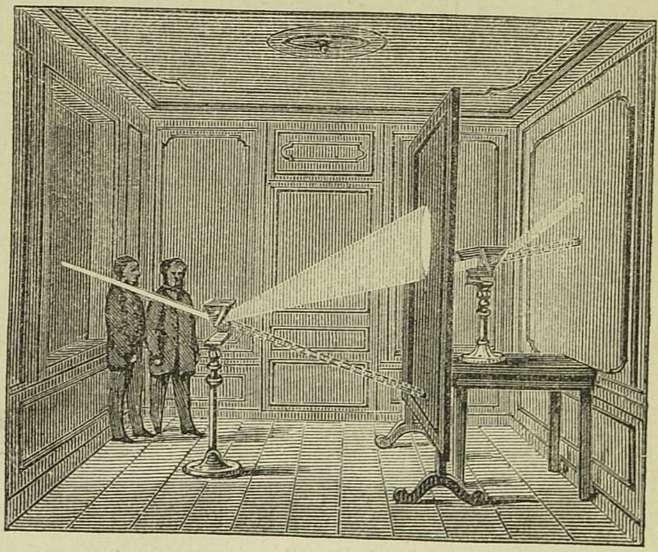
E F, shutter; A B C, prism; W H T I, screen; L, hole in shutter, S, ray of light; P, natural falling place. Coloured band, as projected by prism.

at the top and the red at the bottom when a ray of light is broken into a spectrum by a prism.

The proof of the composite nature of white light Newton thus obtained by what is called *analysis*, or separation of its component rays by means of the prism. He completed his proof by a process which is called *synthesis*, that is, by the putting together again of those component parts.

Thus he found that if an observer takes his stand near the hole in the shutter of the darkened room, and looks at the spectrum projected on the screen, through a prism similar, and similarly placed, to that which forms it, he will see—not the elongated band of prismatic colours—but a round white spot of light; that is, the colours will have been re-composed in passing back from the screen to the eye.

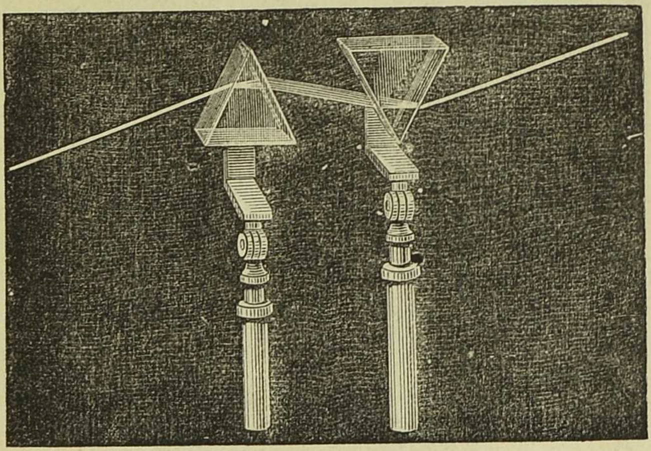
It is obvious from Fig. 1, that the coloured rays in



DARK ROOM, PRISM, AND SPECTRUM. Fig. 1.

their return *from* the screen towards the observer, will be subjected to refractions precisely the counterpart of those which they sustained in their onward course *to* it; so that after passing through the second surface of the prism back into the air again, they come to the eye of the observer stationed near the hole in the shutter, exactly in the condition of the original beam; which is thus shown to be compounded of all the coloured rays that have been brought together again in passing backwards from the screen through the prism, as they were originally separated by it in their passage from the hole in the shutter towards the screen.

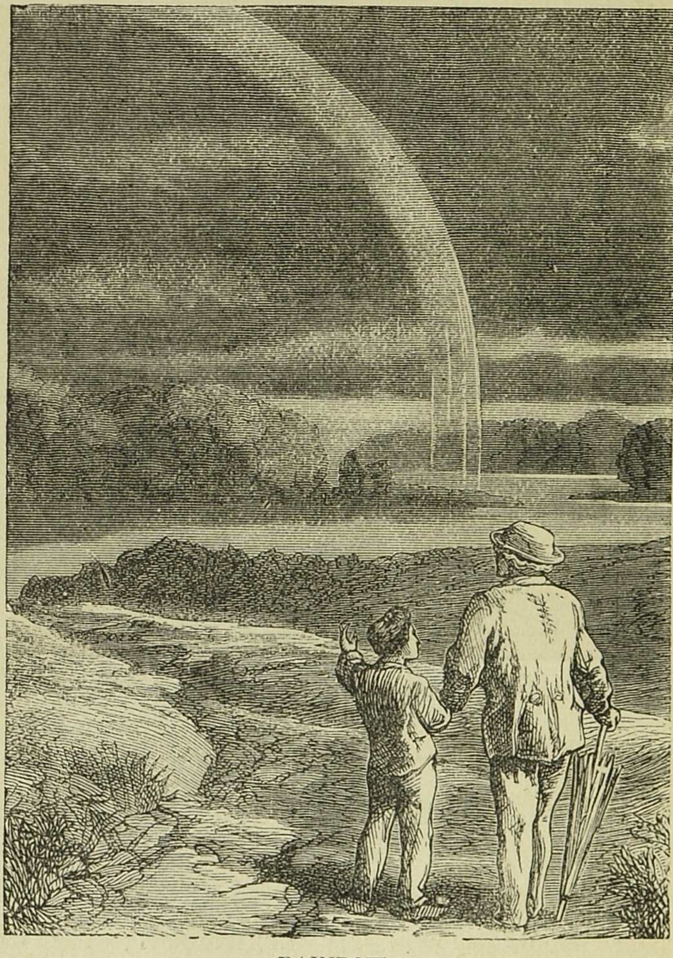
Precisely the same re-combination may be effected by placing a second prism near the first, but in a reversed position, as in Fig. 2: for if the coloured spectrum



DOUBLE PRISM, RE-COMPOSING A RAY OF LIGHT. Fig. 2.

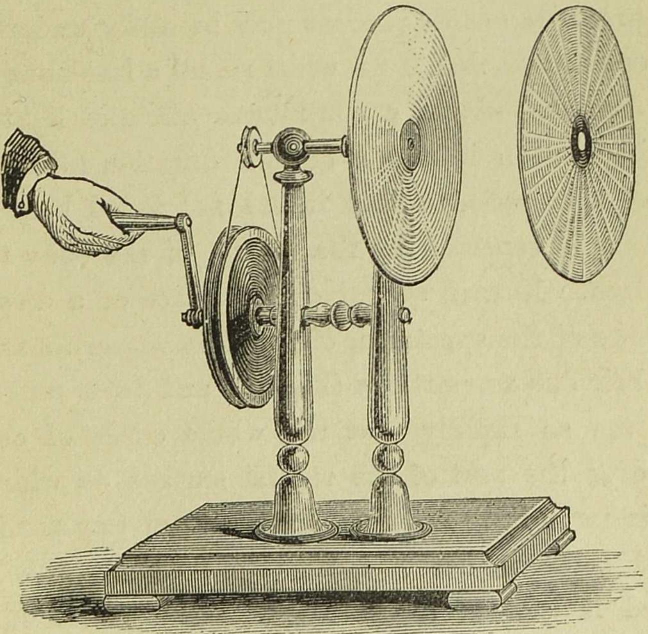
which has been produced by the decomposition of a beam of white light in its passage through the first spectrum, be received upon the oblique side of a second prism of which one of the edges is directed upwards, the effect of the first prism is precisely neutralised; the differing refrangibilities of the differently-coloured rays now tend to bring them together; and a beam of white light issues from the second prism, in a direction parallel to that in which the original beam fell on the first.

Thus Newton found that his prism might be used either to *separate* the beam of white light into the series of diversely coloured rays that form the spectrum or to



RAINBOW.

re-combine the entire series proceeding from that spectrum into a beam of white light. And while the precise correspondence between the "prismatic spectrum" and the "colours of the rainbow" suggested that the rain-drops must act as prisms in decomposing the solar beam, this explanation of the origin of the "bow in the clouds" was confirmed by the entire disappearance of its colours, when a rainbow was viewed through a prism so disposed as to re-combine them.



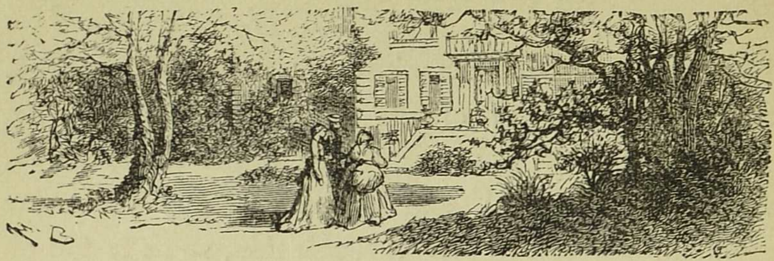
NEWTON'S REVOLVING DISC FOR RE-COMPOSING COLOURS INTO WHITE LIGHT. Fig. 3.

In these cases the re-combination is effected *optically*; that is to say, the second prism is so brought to act upon the differently-refrangible rays which have been "dispersed" by the first, as to make their differences tell in the contrary direction. The same thing may be done by receiving the spectrum on a convex lens, which brings all its rays to one focus, and reproduces the image of the hole in the window-shutter, in white light. But there is another mode in which this re-combination may be made *visually*, that is, by making use of the properties of the sensory apparatus, rather than of those of the prism or lens.

The principle of this process may be easily understood. Every one knows that if we whirl round a luminous body in the dark, we obtain a continuous circle of light; the visual impression having a certain duration (about one-eighth of a second), so that it has not faded before the impression is repeated by the return of the body to the same place. Now if we paint the surface of a disc with the colours of the spectrum, disposed in segments according to their due proportions (Fig. 3), and then make this disc rotate so rapidly that the whole circle of colours passes over the part of the retinal surface on which its image is formed, before the impression of any particular coloured segment has had time to fade out, the effect produced is that of a white disc,—any shade it may exhibit being due to the impossibility of obtaining artificial colours as pure as those of the spectrum itself.

We have now to examine the properties of the Prismatic Spectrum more minutely.

Seven "primary" colours, violet, indigo, blue, green, yellow, orange, and red, having been distinguished in it by Newton, he set himself to determine whether each of these is to be regarded as a pure colour, or whether any of them may be regarded as mixtures ; green, for instance, of blue and yellow, or orange of yellow and red. An aperture being made in the screen on which the spectrum was projected (Fig. 1), and a beam of any particular colour being allowed to pass through this, so as to fall on a second prism placed in the same position as the first, if that colour were pure, the luminous band which its beam would make when projected upon a second screen, would be all of one colour ; whilst, if that colour were mixed, this further analysis would resolve it into its components. In this way Newton was led to the conclusion that all the seven "primary" colours are truly elementary, and that even the intermediate tints are not mere mixtures.



LIGHT.

CHAPTER III.

ITS PRISMATIC SPECTRUM (*continued*).

THE study of the phenomena of light and colours, carried on by the greatest mathematicians and experimentalists of the last century and a half, has led to the general acceptance of what is called the "Undulatory Theory."

According to this theory, the transmission of light to our eyes depends on the undulations or vibratory waves of an "ether" pervading all space, just as sound depends on the propagation, from the sonorous body to our ears, of undulations in the intervening atmosphere. And just as differences of *pitch* in musical tones are due to the rate of the undulations of air, so does it appear that differences in *colour* are due to the rate of the vibrations of the ether.

It has been found possible, by mathematically-exact methods of measurement, to determine that the *number* of undulations which produce the visual sensation of red is four hundred and fifty-eight millions of millions per second; whilst the number of those at the opposite end of the spectrum which produce the sensation of violet is seven hundred and twenty-seven millions of millions per second. Of the several prismatic hues which can be distinguished between the red and the violet, every one has its own proper number, intermediate between four hundred and fifty-eight and seven hundred and twenty-seven million millions. The wave-length of the extreme red ray is two hundred and seventy-one ten-millionths of an inch, whilst that of the extreme violet ray is only one hundred and fifty-five ten-millionths; the intermediate colours having a gradational succession of wave-lengths.

But further, the spectrum is found to contain other rays, which, on account of either the too slow or the too rapid succession of the undulations by which they are transmitted, do not produce any sensation of light or colour, but are detected by other means.

Illuminating or light-giving power is greatest in the *yellow* portion of the spectrum, and diminishes rapidly towards the red on the one side and the blue on the other. Its heating power is very differently distributed. There is scarcely any heat in the blue portion of the spectrum, but little in the yellow, and much more in the red. Its greatest intensity is found *beyond the red*, where there is no light whatever; thence diminishing rapidly with the increase of its distance from the luminous spectrum. In fact, about half of the solar heat-rays falling on the earth are invisible.

The difference between the luminous and the heating rays depends, like the diversity of colours, on differences in their respective *rates* of vibration; the rate being less for the non-luminous heat-rays than it is for the red, just as it is less for the red than it is for the yellow.

Still further, there is yet another kind of rays in the solar spectrum, which show themselves neither in producing colours nor in raising the thermometer, but in producing chemical changes; especially in blackening the salts of silver (on which action the ordinary photographic processes depends), and in enabling living plants to decompose carbonic acid, retaining the carbon in their own substance, and setting free its oxygen.

The red rays of the spectrum have scarcely any of this chemical power, and the yellow rays very little; but its greatest intensity is in the *blue* and *violet* portions of the spectrum, and in the chemical rays which extend, as invisible or non-luminous rays, *beyond the violet* end of the spectrum, the rate of the vibrations which produce these rays being even greater than those which produce the violet.

The entire length of the solar spectrum is, therefore, about double its visible length. The presence of invisible rays beyond its red end may be made sensible by their action on a delicate heat-measuring apparatus, and the extension of invisible rays beyond the violet end may be made sensible by their blackening effect on the "sensitive paper" of the photographer.

Certain substances have the property of being so acted on by these chemical rays, as to become self-luminous. A thick piece of the canary-yellow glass which derives its colour from oxide of uranium, held either in the violet part of the spectrum, or in the dark space immediately beyond it, gives out a faint nebulous light. A similar effect is produced by sulphate of quinine; so that a piece of white paper, washed in a solution of this colourless salt, placed beyond the violet end of the spectrum, gives out a bluish light.

A very pretty experiment is made by writing on a piece of white paper with this solution, and then bringing the paper into the dark ultra-violet portion of the spectrum. The letters traced on the paper, which were previously invisible, now shine with a bluish light, as if they had been written with a stick of phosphorus. This beautiful phenomenon is termed Fluorescence. Thus, the solar spectrum consists not alone of the diversely coloured and visible rays. Some of it is unseen.

The most important stage in the development of spectrum analysis, is the discovery that the solar spectrum is crossed at different points by *dark lines*, which form breaks in its continuity; as if a set of wires were placed across the course of the beam after it has passed through the prism, so as to interrupt the course of the variously coloured rays, and thus to project their shadows on the screen in different parts of the rainbow series.

Some of these lines are broad, others narrow; in some parts of the spectrum they are crowded together, whilst in others there are wide spaces between them.

Though the relative distances of these lines are altered, as are the relative lengths of the differently coloured bands which they cross, by changing the material of the prism, yet with the same prism their distances are uniform for all kinds of solar light, whether the light be that of the direct rays of the sun, the light reflected from a dark cloud, or ordinary diffused daylight. The spectra of the Moon and of Venus show that *their* light also (which is reflected from the sun) exhibits the same lines and in the same positions. But the spectra of Sirius and of others of the more brilliant fixed stars, have each their own set of lines, differing both from the solar spectrum, and from the spectra of other stars.

LIGHT.

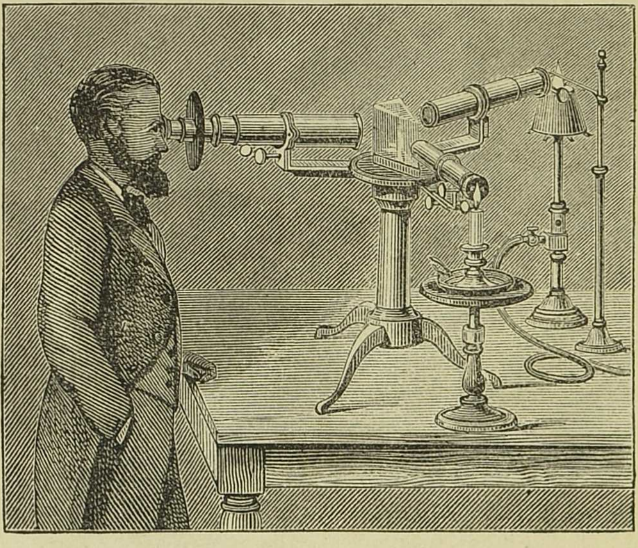
CHAPTER IV.

SPECTRUM ANALYSIS.

THE fundamental principle of the construction of the instrument, now termed a Spectroscope, by which these lines are examined and their positions determined, is extremely simple.

A prism of dense flint-glass having a high dispersive power, or a hollow prism of glass filled with bisulphide of carbon, is set upright on the top of a pillar carrying three arms, as shown on next page in Fig. 4. The arm on the side opposite to the observer carries a tube which has its extremity closed by a shutter containing a very fine slit, the breadth of which can be exactly regulated by a fine micrometer-screw; while, at the end nearer the prism, is a convex lens, which serves to collect the rays issuing from the slit, and to render them parallel before they fall on the prism.

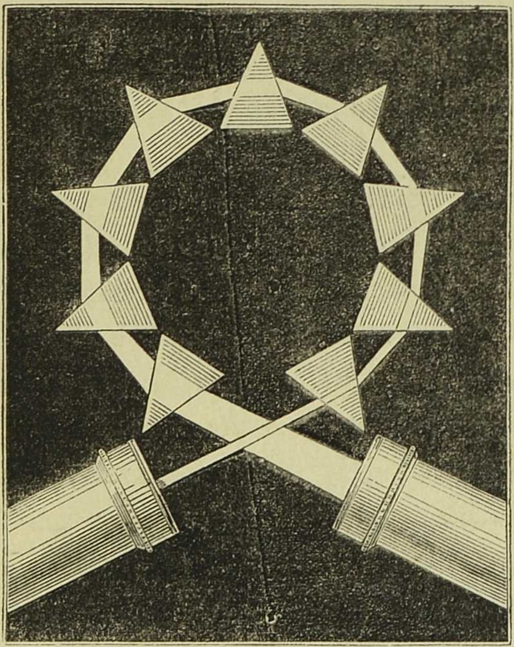
The substance to be examined is introduced into the flame of a Bunsen-burner just outside the slit; and the ray from it which is admitted by the slit, after passing through the prism, and suffering dispersion by its agency, is received into a telescope of low magnifying power,



THE SPECTROSCOPE. Fig. 4.

through which the observer is represented as looking. Only a portion of the spectrum can be seen at a time; but the arm which carries the telescope has a horizontal motion round the pillar, so as to be adjustible to any part of the spectrum; and as the circle round which it moves is divided into degrees, &c., the angular distance between the different lines successively brought into the centre of the field of the telescope can be very exactly measured.

If very exact observations are required, two or more prisms are used, so as to lengthen the spectrum by repeated dispersions, as shown in Fig. 5. In this manner, not only are the lines more widely separated from



LIGHT PASSING THROUGH MANY PRISMS. Fig. 5.

each other, but many of those which with a single-prism spectroscope appear as single lines, are found resolvable into two or more.

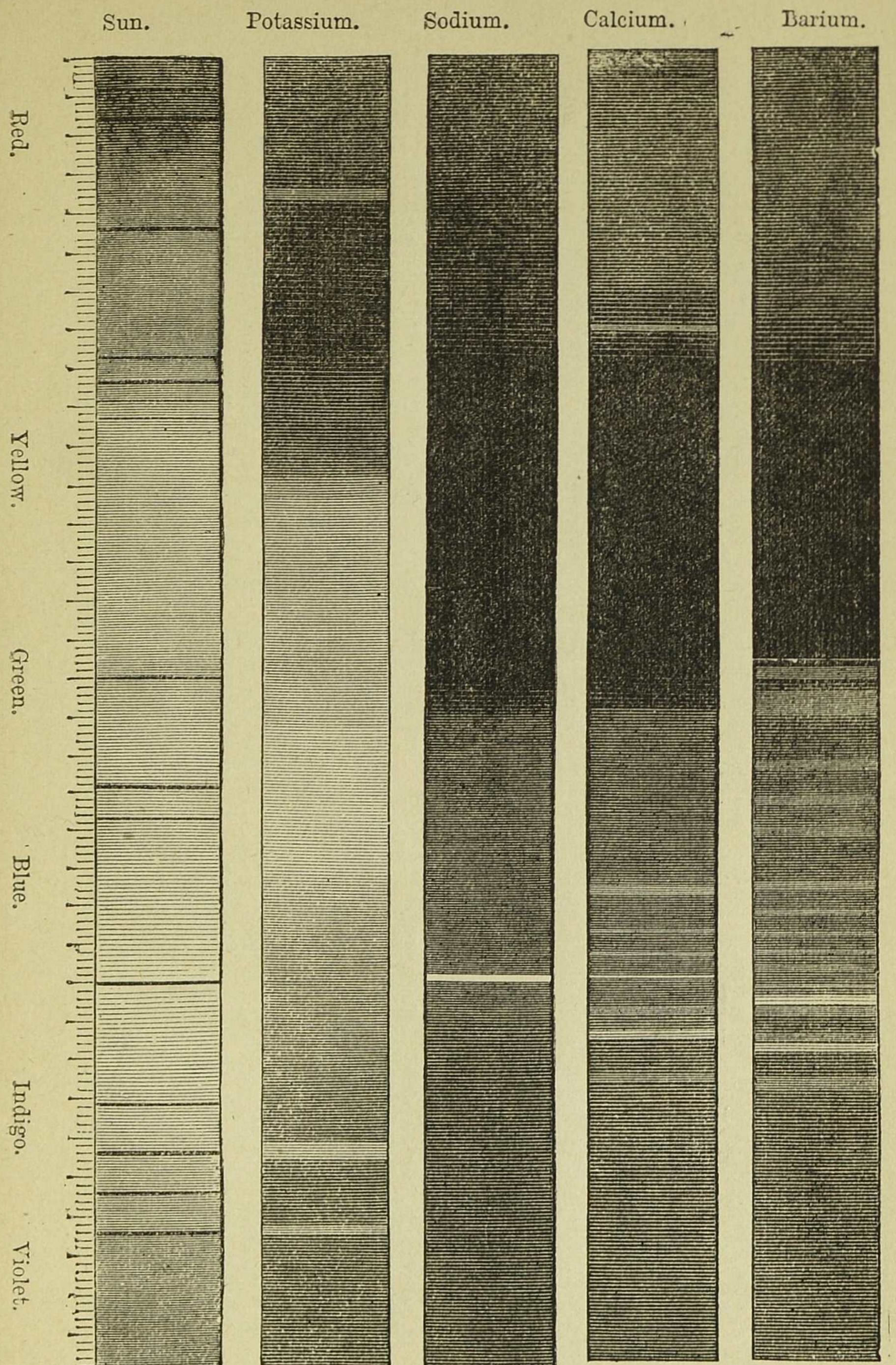
The spectroscope has now become as necessary an instrument as the balance, in the laboratory of the chemist.

A few examples will be given in the first place, to show the extraordinary value of this new and very simple method of visually recognising the presence of *elementary substances*, in amounts so minute as almost to surpass belief.

Of all substances yet examined, there is none that is more universally diffused, or that can be more readily detected, than *sodium*, the bright yellow soda-line has been distinguished, when the quantity of that substance raised into vapour was so minute as 1-180,000,000th of a grain.

It is difficult, in fact, to project any spectrum, in which a faint sodium-line does not show itself. For the dust that is constantly floating in our atmosphere, and forms the motes in a sunbeam, almost always contains sodium; so that if a dusty book (for example) be struck, or a coat be beaten, at some feet from the flame, the bright yellow sodium-line immediately flashes out. Even a platinum wire from which every particle of sodium has been driven off by heating it in the flame, will again show the sodium reaction after being laid by for a few minutes without touching anything, in consequence of the settling-down of dust upon it; and will also exhibit it after being once drawn between the fingers or through the mouth, showing that the cutaneous perspiration and the saliva contain soda-salts.

The cause of this universal presence of soda in the atmosphere at once becomes obvious, when we consider that two-thirds of the surface of the globe are covered



SPECTRA OF LIGHT OF SUN AND OF BURNING MINERALS.

with salt-water; that every wind which traverses the surface of the ocean carries up a film of that surface in the form of fine spray; and that while the watery vapour is held in solution by the air, the particles of salt it contains will be diffused through the atmosphere, and will be carried by its circulation over every part of the surface of the land.

Another interesting result that was early obtained by the use of this new method of research, was the general diffusion of the alkaline earth termed *lithia*.

This earth had previously been known to exist in only four minerals; and a demand having sprung up for it, in consequence of the valuable results obtained from its use in the treatment of gout, this limitation of the supply rendered it very costly. Now a very minute quantity of this earth, when introduced by itself into a non-luminous flame, at once imparts to it a brilliant red; but as it is always naturally found mixed with soda and other substances which are present in much larger quantity, the stronger colour which they give to the flame masks the red of the lithia. When, however, a minute portion of any such mixture is introduced in the flame of the spectroscope, the presence of lithia is at once revealed by a bright line in the red portion of the spectrum, whilst the presence of soda is recognised with equal certainty by its bright yellow line, and that of any other substance by its own line or combination of lines.

Lithia, though seldom occurring in large quantities, is thus found to be one of the most widely distributed of all substances. It is present in sea-water, and in that of most springs (a singl spring in a Cornish mine having been found to pour it forth at the rate of eight hundred pounds of chloride of lithium every twenty-four hours); and being taken up by plants from the water of the soil, it passes from them into the bodies of animals. It is found in bread; in almost all fruits and vegetables; and in wine and beer. So, too, if the end of a cigar be held in the spectroscope flame, the presence of lithia is at once indicated by its characteristic red line.

The flesh, blood, and other fluids of animals will contain it; and the rapidity with which it is absorbed and diffused through them has been experimentally shown to be such, that within ten minutes after a solution of lithia had been injected beneath the skin of a guinea-pig, it was found in every texture and fluid of the body, except the crystalline lens of the eye, which is not penetrated by blood-vessels; while in a few minutes more, it had penetrated even *its* substance.

Experiments have shown that as little as 1-6,000,000th of a grain of lithia can be detected with certainty by spectrum analysis. It is, moreover, a fact of great interest that lithia has been thus detected in meteoric stones; so that we may safely presume upon its extensive diffusion, as one of the materials, not only of the Earth and its inhabitants, but of all the bodies composing the solar system.

The spectra characteristic of nearly all known solid bodies have now been most carefully studied and accurately mapped. Most metals give a great number of lines; and yet between the lines of one and those of another, there are scarcely any coincidences. Not only has each substance its peculiar *luminous* rays :—a like peculiarity exists in those rays of very high refrangibility, which are projected beyond the violet end of the spectrum, and produce chemical effects. The bands peculiar to each substance may be rendered visible by throwing this dark portion of their spectrum upon a piece of paper moistened with a solution of quinine, the "fluorescence" of which will cause it to shine wherever the chemical rays fall upon it; and they may also be made to imprint themselves on photographic paper, in virtue of their chemical action upon it. The non-luminous rays proceeding from the combustion of iron, aluminium, and magnesium, or from electric sparks given off from poles composed of these metals, are so numerous and highly refrangible, as to form distinct bands at a distance beyond the violet ray which is equal to ten times the whole length of the *visible* spectrum, from the violet to the red.

It is also by passing the electric discharge through gases—oxygen, hydrogen, nitrogen, &c.—that their characteristic spectra have been ascertained, and the remarkable fact determined that these spectra in many instances vary considerably according to the *pressure* to which the gas is subjected at the time. This fact will be shown to have a most important application in solar chemistry.

We now reach the discoveries in spectrum analysis, by means of which its use was extended from the study of the terrestrial elements, to that of the components not only of the Sun, but of the remotest bodies in the celestial universe; and by which not merely their composition, but the incessant changes of which they are the subjects, have been discovered and exactly measured.

LIGHT.

CHAPTER V.

MIRAGE, MOCK SUNS, ETC.

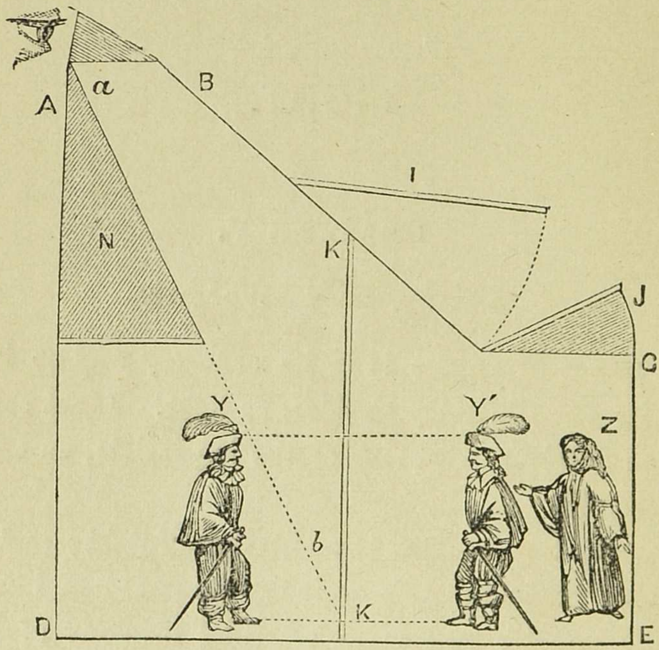
NO power of nature is in its ordinary way so true, in its extraordinary so false, as light. Light can be a strange deceiver, a worker of the impossible, an enchanting wizard !

Pepper's Ghost—that is an illusion of light ; and as the mode of producing this well-known phantom illustrates the far grander and more startling illusions of the air and sky, let us briefly explain.

Interesting as a sight of the ghost may be, the means by which it is produced should be more interesting still.

First of all, then, what is the ghost ?

Two or more figures appear on a stage, and the spectators view them from a distant, darkened, and elevated portion of the building. From this point the two figures appear solid, real, living. Now one of them is merely visionary. The visionary figure is, of course, the ghost, whilst the real figure is the alarmed man. The ghost can, of course, whenever the plot requires, fade away, appear to pass through a closed door or solid wall, or play any other ghost-like antic. The ghost is a figure made of light.



BOX PHANTOM.

Now, *how* is this ghost made? How is a man-like figure—face, hands, legs, clothes and all—made of light? The answer will be best understood by a reference to our figure, which, by the way, is of an apparatus the reader may make for himself.

There is a box—A B C D E—which is closed on all sides, but provided on one side with the door E, and on the other with the door G, hinged to the back A D. On the top of this box are the flapped openings I and J; the interior of the box is divided centrally by the partition K K, made of a good, clear, and even-surfaced piece of thin patent plate-glass, kept in its place within two side grooves. The box by this glass is divided into two separate chambers, the left-hand one having a screen, N, to exclude its floor from the view of the spectator, as shown by the line *a b*.

Now let two figures be introduced, one Y, the other Z; then let the eye of the spectator be fixed at A. He will now observe two figures, one real, Z, the other visionary, Y′, the mere reflection of the real Y. By this arrangement it is evident that the plain unsilvered glass, when viewed at an angle of about forty-five degrees, has all the properties of a mirror, but owing to its transparency two figures are seen, both apparently alike solid and real.

A person placed at Z will see only the figure Y; but as a piece of acting may, under proper arrangements of a suitable stage, approach the situation apparently occupied by Y, and thus indicate to a spectator placed at A any pre-arranged dramatic scene.

But if we would see the illusions of light on a vaster, grander scale, let us leave the experiments of man and listen to one of Nature's stories as told by an Eastern traveller.

Whilst crossing part of the desert where all was mere waste of sand, there appeared a large sheet of calm water surrounded by palm-trees, in whose recesses, says he, we perceived the white walls of houses, long groves of palm-trees, and, rising above their plumes, a tall minaret. This could be nothing less than a town. So real was the

MIRAGE ON SAND PLAINS OF MEXICO—LAKE, TREES, AND MOUNTAINS.

thrice welcome sight, that our parched, weary men and camels pushed forward with the vigour of new hope, longing to bathe in the refreshing waters, and shelter from the burning sun beneath the roofs of this shady town. But, alas! as we advance, illusion became apparent, a mirage vanished in a moment; sun, sand, desert, these were all that remained of the beautiful but miserable mockery.

How come these things to pass? The sand is intensely hot. The layer of air which rests upon it is therefore greatly rarefied; and under certain circumstances this layer is as distinct from the denser stratum a few inches or feet above it, as a thick sheet of glass would be distinct from a sheet of water on which it might be made to rest. The effect of this arrangement of the air is the same as if a vast mirror were held above the land, level with it, the reflecting side down—a mirror, however, which has not a perfectly even surface, and which, therefore, reflects things in a somewhat distorted manner.

In Egypt, where this mirage was witnessed, the villages are built upon eminences which rise from the plain. The houses are reflected from the surface of the two layers of air, just, as we have said, as if that surface were a vast mirror held over them, extending to the plain. The reflected trees and houses are, of course, in fairy and more fantastic proportions. The same general cause produces the effect of a sheet of water.

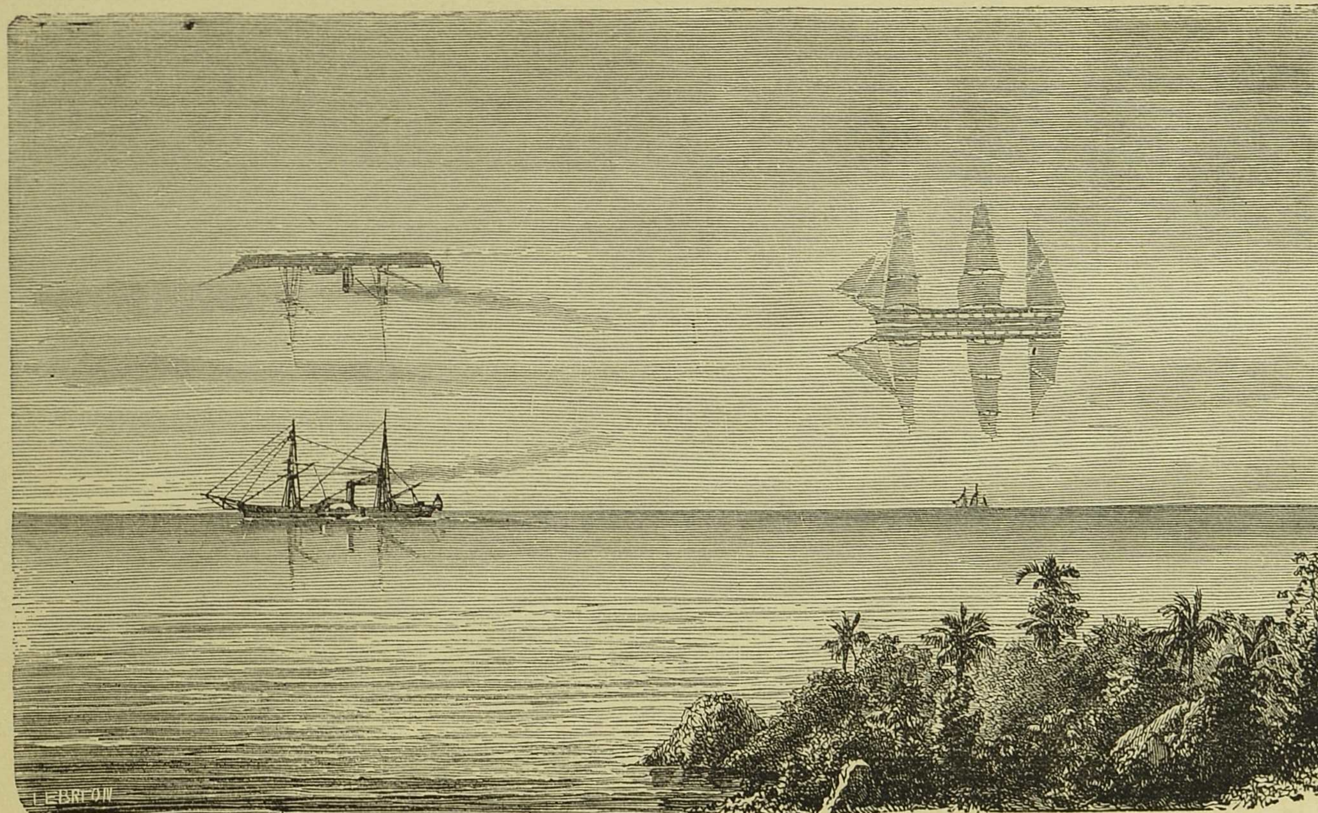
The mirage is produced almost wherever there is a wide surface of hot sand, for there the air resting upon it can be divided into layers of different densities, the conditions of the mirror are found, and the mirage is formed.

These atmospheric mirrors are not all at the same height above the ground, so that they reflect from different parts to the same place. They are not always level, nor are they always at the same angle, so that curious and unnatural groups of things are sometimes brought together. Of this fact the mirage is a well-known illustration.

Very curious illusions are seen on the Straits of Messina, called by the Italians *Fata Morgana.* This is the story of an eye-witness :—

"As I stood at my window, I was surprised with a most wonderful delectable vision. The sea that washes the Sicilian shore swelled up for the distance of ten miles, like a chain of dark mountains; while the waters near the Calabrian shore grew quite smooth, and, in an instant, appeared as one clear polished mirror, reclining against the aforesaid ridge. On this glass was depicted, in chiaroscuro, a string of several thousands of pilasters, all equal in altitude, distance, and degree of light and shade. In a moment they lost half their height, and bent into arcades like Roman aqueducts. A long cornice was next formed on the top, and above it rose castles innumerable, all perfectly alike. These soon split into towers, which were shortly after lost in colonnades, and at last ended in pines, cypresses, and other trees even and similar. This was the *Fata Morgana,* which for twenty-six years I had thought a mere fable."

The mirror theory explains this illusion as well as that of the mirage; but to produce the *Fata Morgana* the observer must be above the level of the reflectors.



MIRAGE AT SEA.

Sometimes the reflecting surface is above the eye at sea, then a reflection of a ship or steamer is seen like that given in the illustration. Any one may readily see the repetition of this if he will hold a hand-glass parallel to the surface of a table at a little height above some object, and then lowering the eye to the level of the table look up at the glass. He will see the object upside down, just as high above the glass as the glass is high above the table. This explains the case of the steamer.

The double and inverted reflection of the three-masted ship is accounted for in the same general way, but with particular explanations, which make it somewhat more complicated. Ships are sometimes reflected thirty or forty miles away from their place on the sea.

An illustration will help to a realisation of the facts. Get an empty bowl, a shilling, and a jug of water. Put the bowl on a table, place the shilling in it, and give the jug of water to a friend; fix your eye on the shilling, and then step backwards from the table till the shilling is just hidden by the rim of the vessel. Then stand still, ask your friend to pour the jug of water into the bowl, still keeping your eye on the part of the bowl at which you saw the shilling disappear. The water being poured, will, without your moving a step, bring back the shilling into sight. How is this? You and the coin are exactly as you were when the bowl was empty and the shilling invisible. The reason is here: the ray of light when passing from your eye to the shilling in the empty bowl was straight, and you drew back till the edge of the bowl came in that straight line and cut off your sight. Now the line of sight is *not* straight; it has been bent in passing out of the water, and you are now able, as it were, to see round a bend. This is something like what takes place in the mirage which brings distant objects to sight.

As in the case of the shilling in the bowl, you see, as it were, round a bend, so the rays from ships at sea are bent in passing through atmosphere of water-like density. This is effected, not by what is commonly called the reflection of light, but the refraction of it.

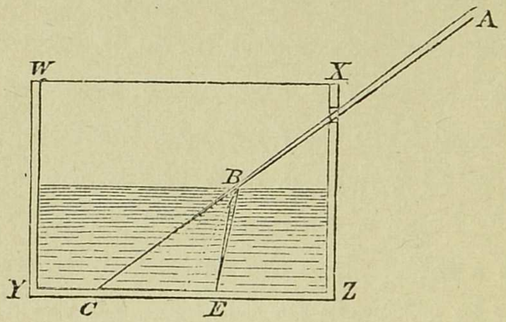


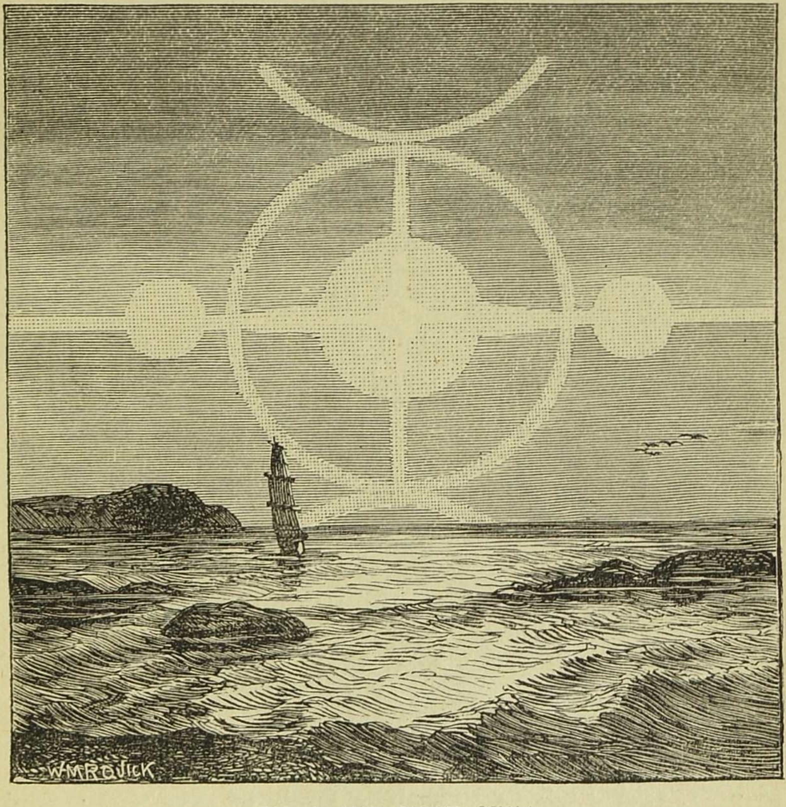
ILLUSTRATION OF REFRACTION.

W X Y Z, vessel containing water; E, real position of shilling; C, apparent position; B, surface of water; A, position of the eye.

The fact is shown in the diagram; the shilling is actually at E, it appears from the point of the eye at A to be at C, but the ray of light is really bent at the point B.

This general law acts under very varying conditions. Sometimes it acts on objects below the horizon and out of the range of vision, lifts them up into mid-air and suspends them there; sometimes it exhibits objects in their natural position, sometimes it inverts them, and sometimes it shows them both ways at once, right and wrong side up, and at the same time and place; and sometimes it presents a kind of jumble.

Of this first class Captain Scoresby gives a striking



HALO AND MOCK SUNS.

instance. It occurred in the Arctic Seas. The inverted image of a ship was apparently suspended in the air, some miles distant. "It was," he writes, "so well defined that I could distinguish, by a telescope, every sail, the general rig of the ship, and its particular character, insomuch that I pronounced it to be my father's ship, the *Fame*, which it afterwards proved to be, though on comparing notes with my father when we met, I found that our relative position at the time gave our distance from one another very nearly thirty miles, being about seventeen miles beyond the horizon, and some leagues beyond the limit of direct vision."

The captain of H.M.S. *Archer* saw in the Baltic a mirage of the whole British fleet, consisting of nineteen sail, whilst the fleet was thirty miles away. In both these instances the objects seen were inverted.

A few years ago the whole of the coast of France from Calais to Dieppe was seen in mirage. The coast is fifty miles distant. It appeared not inverted, but in its natural position, and remained visible for three hours.

Other peculiar forms of atmospheric illusions are known as mock suns and Ulloa's circles. Clouds formed of snow crystals exist in the higher regions of the atmosphere, where they constitute those clouds which are known as cirrus. The very singular effect known as mock suns is produced by the rays of the sun, and sometimes by those of the moon, striking upon these snow-crystal clouds. Halos, such as are seen round the moon on a slightly misty night, are the effect of this kind of cloud. Our illustration is of a comparatively rare sight in Iceland, which happens to the sun when he is near the horizon. Of these rings, the white round balls of light formed outside the centre are called mock suns and mock moons, according whether the sun or moon be the centre. Some parts of the circles, especially near to the centre, are tinted with rainbow hues.

Ulloa's circles take their name from the traveller who first described them. M. Ulloa says:—

"I was with M. Bouguer and our fellow-travellers, one morning at daybreak, on the summit of the Pambamarca. The whole of the mountain-top was covered with a dense fog. Gradually the fog dispersed and the sun rose. By degrees the atmosphere became tolerably clear, with the exception of a few light vaporous clouds, so filmy as to be scarcely perceptible. While we were watching the gradual disappearance of the clouds, one of our number turned round to that quarter of the sky which was exactly opposite to the rising sun, and suddenly he perceived his own image reflected, just as though a large mirror had been placed at about the distance of twelve feet from him.

"The image stood in the centre of three concentric, shaded, and different coloured rings. The outermost edge of each was crimson, the next colour was orange, which shaded off through yellow into a pale straw, finishing inside with green; around the whole was a fourth ring of one colour alone.

"The figure, and, what is more remarkable, the surrounding rings too, followed every movement of the observer, the image of his head forming their centre. At first the rings were somewhat oval in shape, gradually they became a perfect circle, and as the sun rose in the heavens they increased in size; then the colours of the rings grew faint, and with this the figure also. After a few minutes it faded away."

At the exclamation of the first discoverer of this scene, every one of the party turned round, and, strange to say, each saw precisely the same appearance, happening, however, not to his fellow-traveller, but to himself, and each fancied that the event was happening to him alone.

These phenomena were caused by the peculiar position of the sun acting on floating vapours, on the same principle as in the case of an ordinary rainbow.

METEORIC SHOWERS, ETC.

METEORIC SHOWERS, ETC.

CHAPTER I.

METEORIC SHOWERS, THEIR APPEARANCE.

ONE of the grandest sights of this century was the meteoric shower of November 14th, 1866. Thousands upon thousands of momentary lights with fiery trails, and of many hues, lit up the landscape and the midnight sky, and spread often in volleys like fans of rockets over the blue vault and amidst the stars of heaven, and that incessantly and for a long space of time.

A meteoric shower has been compared to a display of a countless number of rockets; but there is this notable difference. There is the consciousness that rockets have a human birthplace, and there is the whirr, and the hiss, and the boom, the inevitable attendants on the busy works of man; but here, in the unbroken stillness of the night, we have the fairy scene of some high festival of celestial spirits, illuminations devised and lighted by no human hands, but starting into brightness in all the majesty of the depth of utter silence. There are fires unearthly and innumerable, but there is no sound.

An earthquake may be more terrible in the mysterious heaving or the crash, yet the terror is the terror of a moment; an eclipse of the sun may be more gorgeous, and appalling, and strange, yet that gloomy standstill of universal nature is gone in the space of minutes few to count, though never to be forgotten; but in this November star-shower the spectacle rose, and culminated, and fell with a gradation and a magnificence which kept the spectator entranced for a full hour together. It is and will be the sight of the century.

The world had been duly informed by the daily journals that an unusually grand display of meteors might be expected during the early morning hours of the 13th or the 14th of November.

About this period of the year, namely, from the 9th to the 14th of November, shooting stars are commonly seen in considerable abundance; but Professor Newton, of Yale College in America, by searching ancient records, had discovered that three times in about every century the November display had hitherto attained to a remarkable magnificence.

The writer took his stand on a hill some hundred and fifty feet above the level of the sea, not far from the western extremity of the Isle of Wight.

METEORIC SHOWER AT SEA.

A A

The night, or rather the early morning, of the 13th, was watched with intense anxiety. Wind and cloud and rain soon dashed our expectations, and we could only hope that other observers were favoured with better weather than ourselves, but have since learned that almost throughout the country they were doomed to similar disappointment, and in their turns were wishing a better fate for us.

At intervals, however, during the early morning, there were occasional breaks in the clouds, and now and then, had bright meteors existed in any abundance, some of them must have been seen. But the heavens gave no sign. Thus, none having been recorded by any of our watchers, we consoled ourselves that the 14th rather than the 13th might yet remain to be fulfilled. With this forced but consolatory hope, we discontinued our fruitless watch and went to bed.

The late hours of the evening of Tuesday, November 13th, were such as we had longed to see.

At one minute before midnight we first looked through a large window commanding the north-west nearly to the north-east, and before we had time to exclaim, "What a magnificent sky!" the train of a bright meteor sailed before our eyes. A moment after a second meteor shot. The long-expected display had commenced. We were looking at the first droppings of a November fire-shower. Fifty-five meteors followed in the next twenty-six minutes, at the rate of two per minute. The fiery shower was clearly commencing in right earnest.

After the lapse of a few minutes, it became evident to the writer that any attempt to count the number of the meteors with an available amount of precision must, by dint of their very abundance, prove abortive; he and another watcher therefore agreed to keep their eyes well fixed upon the neighbourhood of "*the Sickle*," and simply count the number of the shooting stars which pelted or pierced the constellation Orion, and meanwhile the other inmates of the house were directed to watch things in general, and record any circumstance which seemed more striking than the rest.

At one o'clock in the morning not a cloud obscured a single star in the heavens, from north to south, and from the horizon to the zenith: the stars had trimmed their lights as for some high festival.

From 12h. 30m. to 1h. 30m. the star-storm waxed, and culminated, and waned. At 12h. 30m. the fiery trains shot into or through Orion at the rate of two per minute, and with a velocity probably of some thirty miles per second. By 1h. the pelting had increased to five per minute; at 1h. 5m. it was at the rate of six; at 1h. 12m. it was at the rate of eight. Soon after this a long dark rain-cloud for a time intercepted our view of this now much-suffering but famous hunter of ancient days. When we next saw him at 2h. the fiery wounds were reduced to three only in the minute, and half an hour after the rate was two; while at 3h. it had subsided to about nine in ten minutes. Thus it was evident that our part of the earth was now clear of the thick of the sparkling storm.

During all this grand spectacle, the reader must remember that our counting and our eyes were directed to but one inconsiderable patch of the heavens, in fact to a single constellation. To other eyes the meteor trains were starting in all directions over the whole expanse of the sky.

Between the hours of one and two in the morning, a single person looking east counted nearly fifteen hundred, and many must have been missed. At three minutes past one sixty were counted in a minute; in the next minute sixty again, and then thirty, and then thirty-six, and then thirty-four, and at seven minutes past one the number suddenly shot up to sixty-four, and in the next waned to thirty-eight. Thus the meteors evidently came, as has been already stated, and as we saw them, ofttimes in volleys, and spread over the sky like the ends of the veins of an open fan.

Every now and then there would break out a little bright fiery spangle, burning for a moment or two without a train, and then gradually going out. At first these apparitions puzzled us. Once the writer rubbed his eyes, to see or to feel if there were something wrong with him.

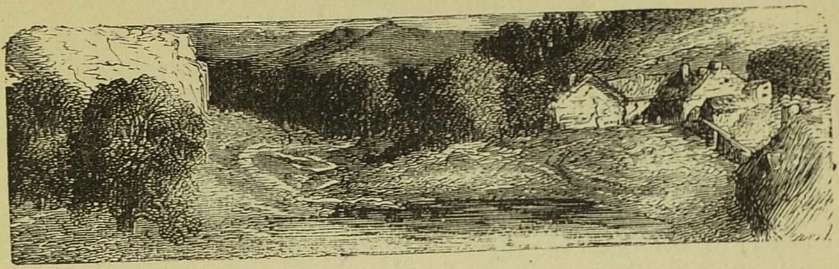
The meteors mostly resembled the trails of squibs or rockets, and were of various lengths, hues, and directions.

Some fire-balls, however, shot with long trains, dissolved, and spread rather than burst into fleecy fiery clouds, which remained visible for nearly four minutes.

What struck us almost as much as any other phenomenon of the whole spectacle was the ominous noiselessness—the dead, utter silence of the entire display.

At the great solar eclipse of 1860, viewed from the Spanish mountains, the shadow of the moon shot from Bilbao to his station at Gujuli, covering in an instant, as with the rapid motion of a shawl, the entire intervening country, and wrapping it in sudden darkness, it was almost impossible not to believe that the imaginary shawl passed by with a whiff and a wind, whereas all was in reality as motionless as death. So now, in the midst of all these fiery trains, it was difficult for us to silence the imagination, and hear with the mind's ear no hissing and no sound. The fall of these celestial rockets is as silent as a fall of snow.

Such was the November star-shower as we saw it from our lovely watch-place. It was a night much to be remembered; an epoch in the lines of those who were permitted merely to see the beauty of the spectacle, much more so to those who could read something of the grandeur of its meaning.



METEORIC SHOWERS, ETC.

CHAPTER II.

METEORIC SHOWERS, THEIR MEANING.

AND now, what was the meaning of the things we have described?

The enthusiasm and emotion of the midnight watch does not cease when we come to explain the meaning and causes of this remarkable phenomena.

Somehow these meteors get mixed up with the whole theory of the universe; to grasp or to explain the little that we know of them, we have to traverse almost the whole domain of scientific knowledge.

To proceed. We have good reason to believe that the spaces between are not mere voids as they were once supposed to be. Almost during the memory of living men nearly ninety masses, revolving round the sun between the orbits of Mars and Jupiter, have already been added to the planetary system, and every year of late has contributed to swell their number. These masses are very much smaller than those of the well-known planets, and in fact most of them are too small to admit as yet of weight or measurement.

But besides these there are rings of matter, of disconnected matter, revolving round the sun as the planets do, and these small bodies thus arranged in rings may be regarded as planet-making dust. Their weight varies from a few grains to possibly as many pounds.

These rings of planet-making dust appear to lie at various distances from the sun, and are of variable thicknesses. Moreover there are other very much larger masses of planet-making dust of hundredweights and tons rather than of grains and ounces weight, which circulate round the sun in very eccentric orbits like the comets.

We begin to think also that those mysterious appendages to Saturn, which we call his rings, and which in the most powerful telescopes and to the sharpest and most scrutinising eyes appear to be numerous, are nothing more than the same sort of dust rings which we have seen circulate round the sun. It is quite certain that *through* one of these rings the body of the planet is visible. Akin to these may be that *something* which surrounds the sun like a thick lens.

Thus, as in the organic world, the microscope discloses all things, whether drop, or dust, or mote, to be teeming with life, so in the interplanetary spaces, which to the

FALLING OF A METEORIC STONE.

unaided eye seem so clear, so transparent, so void, science and the telescope reveal the existence of myriads upon myriads of inorganic bodies.

Such being the case, it cannot but be that our atmosphere must sometimes, and perhaps continually, come into collision with not a few of these fiery planets swarming round the sun, almost as thickly as bees swarm round their queen.

We must here note the speed at which these planet-dust clouds move. This varies from almost nothing to the terrific speed of some forty or fifty miles *per second*, according as the earth and the planetary dust happen to be moving in the same or in opposite directions. When in opposite directions no material in this world could escape melting, and vaporising into ignited gas, by the reason of the heat evolved by friction against the air.

If the collision occur in a clear night, and the meteoric mass be small, we shall have the appearance of a shooting star with a tail only; if it be larger, we may have a fire-ball and tail; if larger still, we may have the spectacle of a fiery mass splitting into pieces with a crash and a boom, and then scattered over a larger or a smaller portion of the fields below, as shown in the picture.

If it occur in broad daylight, the collision will in general, but not in extreme cases, escape notice, and the only result will be, first, invisible gaseous products in the air, and an unnoticed deposit of fine meteoric dust on the ground.

Such, then, is the origin of meteoric showers.

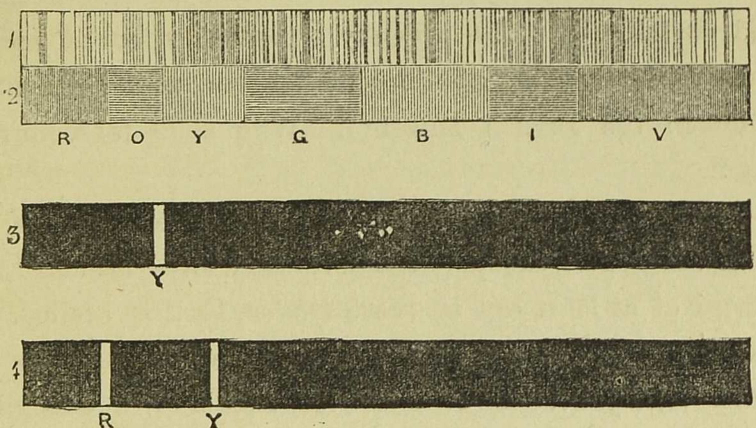
Let us now ask, What is the material of these strange bodies? What are they made of?

They sometimes split into pieces high in the mid-air, and occasionally strew the ground in their fall. Specimens of their fragments may be seen in almost every museum. On submitting them to chemical analysis they are found to consist most frequently of iron, in general mixed with nickel, and various compounds of magnesia and silica, and in some instances just those very ingredients which are seen in what are called the trap and basaltic rocks which lie inside our own earth.

These fiery messengers, then, bring with them tidings from the distant regions of space, that matter therein abounds similar to the matter which constitutes part of our own planet. And not only so, they serve to confirm what modern skill has been able to detect regarding the matter of the stars, nay, of the very sun himself.

It may seem a bold and a strange assertion to state that we possess any certain knowledge of the mineral constitution of bodies so inconceivably remote from us that we have no means to measure their distances, and if we had the means we possess no arithmetic which could convey any intelligible conception of the number of the miles. But so it is. By analyzing light we can detect the material nature of the source from whence it comes, whether it be from the flame of iron, or of nickel, or magnesium, or sodium. The light from the sun and from the stars is thus made to tell that these very metals are burning in those worlds. In the diagrams will be seen the resemblance, and also the difference, between the sun's spectrum and that of this busy world.

The masses of meteoric stones which are the neighbours of the distant sun and of the more distant stars rather than of ourselves and of our own world, tell the same tale as their rays of light tell, and confirm all our scientific conjectures.



SPECTRA.

1. Spectrum of sun, showing its lines. 2. Spectrum of sun, showing its colours. 3. Of sodium, showing its yellow line. 4. Of lithium, showing its red and yellow lines.

Thus suns and stars and comets and nebulæ, and the meteoric fragments which are sometimes spread upon our fields, are all bound together in one common material relationship.

But these are not all the tales which these messengers from the realms of space can tell us, for they bear within themselves further records of their own history. First, they carry with them unquestionable indications that at one period they were like the photosphere of the sun, in the state of gas, in the state of intensely heated incandescent gas.

As to whence came that heat, no philosopher as yet has been endued with genius adequate to the unravelment of the mystery. When these things are known, if that time ever come, then we shall know more of the origin of the earth we live on, and of the sun which cherishes and sustains it. The mystery is probably locked up in those half-burnt, strange-looking masses, which are now lying in the British Museum. Who shall fashion the key?

These meteoric masses carry with them, secondly, some records of the places where they have been. It is related of at least one of these stones, as they are called, that for a long time after its fall it was impossible to touch it, by reason of the—the reader will naturally expect to find the *heat;* but no, quite the reverse—the *cold,* which was insufferably intense.

This fact carries with it the evidence of two things. The first is the evidence of the intense cold, the utter negation of all heat, in the interplanetary spaces where the stone had been for ages wont to move. Dr. Tyndall has recently shown, that so cold is space were it not for the canopy of watery vapour which envelopes our earth, it would, during the night, become by radiation so intensely cold that nothing endued with life could survive. These meteoric stones have no atmospheres, and so they are chilled indeed; and when they fall, although their surfaces for a time retain the heat of their fusion, they sometimes carry with them at the core the temperature of the distant homes from whence they come.

But now, what good are they?

Well, if for nothing else, these things exist for us to look at, and to guess at, not to wonder at. They exist at all events, lest cotton, and railroads, and banks, and shares, and Bessemer steel engross all our thoughts, and at last reduce us lower than the senselessness of a meteoric lump. They serve also to sharpen and improve that bright ethereal gift of God, wherewith for some high purposes His creatures are endowed, the human mind. And that human mind, when thus improved, grows in knowledge; and knowledge, rightly directed, grows up into admiration, and admiration kindles into love.

Three hundred years ago, when the fiery rain shot along the skies, when the very stars seemed to fall from their courses, men were appalled, and they hid themselves in terror, fearing that the crack of doom was at their heels. To-day, God's well-instructed creatures look steadily at the fiery spectacle, not only without a shudder, but they hear, or they might hear, from these strange visitors how completely all things are under their great Father's control, and feel like children peacefully walking up and down in that Father's abode, gazing with joy at the bright treasures of His house.

METEORIC SHOWERS, ETC.

CHAPTER III.

THE ATMOSPHERE OF A WORLD ON FIRE.

MEN and women during 1867 were going on pretty much in the old quiet way of their daily routine, little aware that all along there was visible one of the most strange and unexpected phenomena yet disclosed to the human mind—a star, or rather the atmosphere of a star, on fire!

The star in question was one which we are wont to call "a small one," and certainly it is a very distant one. Had it been otherwise, had the catastrophe occurred to Jupiter, for instance, or to the Dog Star, or even among the Pleiades, it might have been difficult for the majority of men to quiet their expectations or to control their fears.

I have told you this happened in 1837; but strange to say, I cannot tell you *when* this outburst in reality occurred. The fiery message from the stars does not reach our earth in the brief flash of a moment, like the electric thrill from Europe to Newfoundland. The phenomenon of which I speak, though first observed on the 12th of May, 1867, *might* have happened centuries ago, and *could not* have happened within the preceding three years. But of this I shall speak again.

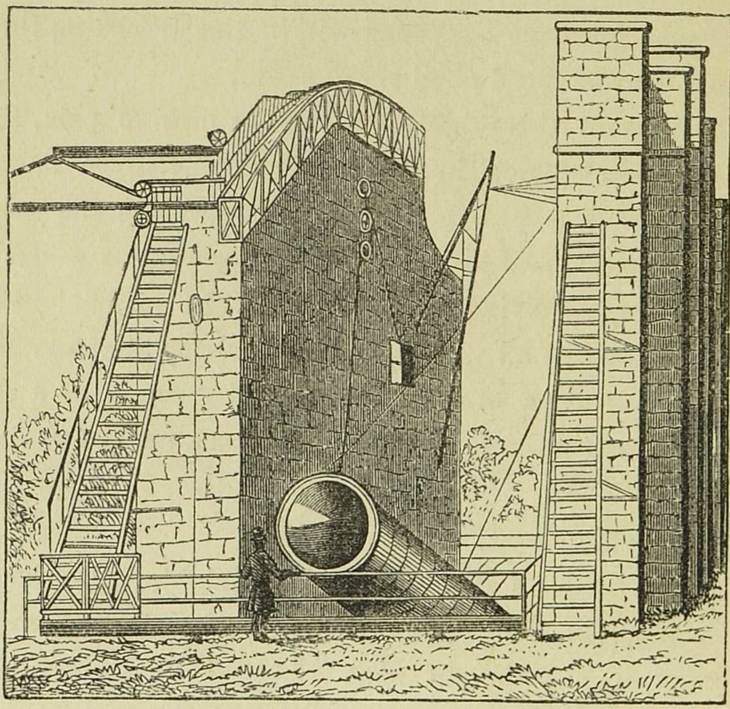
The seat of this mighty outburst is now so pale, that an instrument which, in the hands of the great Tuscan philosopher, was powerful enough to disclose the satellites of Jupiter, and revealed to him the ancient secret of systems of revolving worlds, would be insufficient to make this star at all visible. Nevertheless, the story of a vast conflagration in this, to us, faint spangle of a distant sun, was written by no human hand on the vault of heaven.

Now for the story.

On the 12th of May, near to midnight, a gentleman well versed in the configurations of the starry heavens observed a new bright star. Less than three hours before this the star was not visible. Consequently we have here unquestionable evidence of the sudden appearance of a star. If previously visible at all, it must have been of one-sixth of its then size.

Now consider what this state of things implies.

Conceive for a moment what would be the case with ourselves if on some given day, between the hours of eleven and two, our sun were suddenly to blaze forth with *six times* its ordinary splendour, and with six times its ordinary heat. Surely there would be a pause in the bolting of armour-plate and in the casting of conical shot; the whirl of the cotton-mill and the clang of the hammer would be hushed; the mart would be deserted,

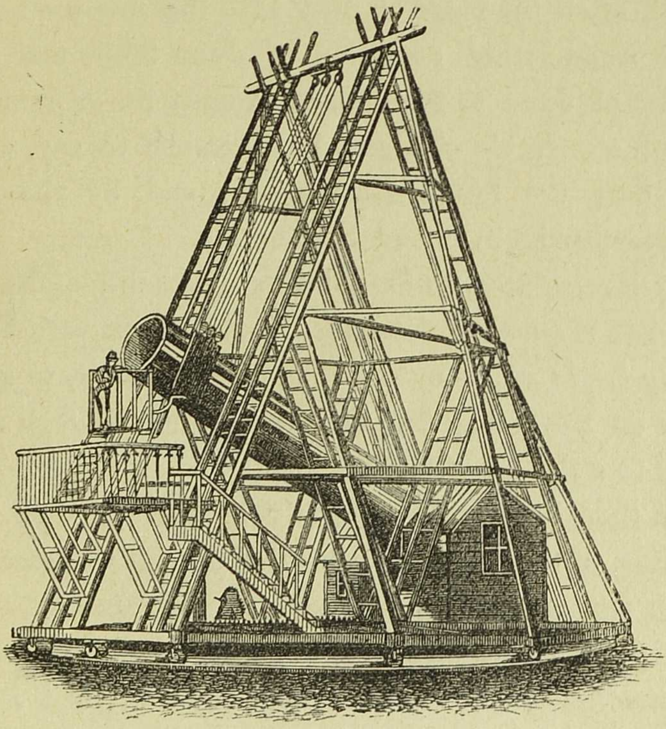


TELESCOPE OF LORD ROSSE.

and trafficking in shares would come to an end. Surely great would be the searchings of spirit, and the thoughts of many hearts would be revealed.

Yet something of this sort must have occurred in the systems which revolved or still revolve round that distant sun. Meanwhile we mortals worked and slept.

'On the 15th of May this remarkable star had decreased from the second magnitude to nearer the fourth. It then continued to diminish with very great rapidity, until on the 26th of June it had sunk to nearly the *tenth* magni-



TELESCOPE OF HERSCHEL.

tude, and thus had ceased to be visible excepting in excellent telescopes.

Now think a moment as to what this fact means. It means this, that the intensity of the star's light rose to fully five hundred times greater than its normal condition, and then sank back again to what it was before.

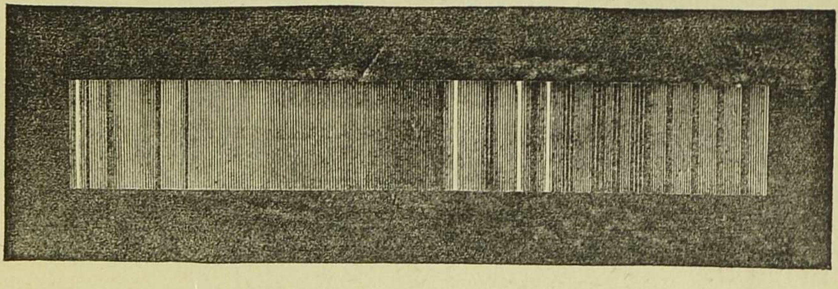
Then as to the variations in *colour*. When first seen there was a bluish tinge, as if the yellow of the star were seen through an overlying film of a blue tint. After the 25th of May this bluish tinge disappeared, and the colour changed through many various tints of orange and yellow.

Well, after the blaze of May 12th the fire went down to the smouldering condition of June 26th, and from the 26th of June to the 20th of August things remained without observable change; but, strange to say, at the latter date the fire kindled again, and by the 15th of September its light had become *sixfold* greater. The star then remained at this point until the 9th of November, when it once more declined. Its colour varied from a *pretty bright yellow* on the 17th of September, to a *light orange* on November 6th, and then faded through a *dull orange* to a *dullish white*.

Our thoughts would naturally be carried back three centuries, to the days of Tycho Brahe, who witnessed the sudden apparition of a new star, in brilliancy exceeding the brightest in the heavens, but which he was sure had not been visible half an hour before. The great Danish astronomer, unfortunately for us, had not the means and appliances which since his day have accumulated in the hands of modern observers, and little else was left for him to do but to gaze, and to guess, and to be astonished.

Science, however, during the last few years has taken one of those sudden bounds which has prepared some better things for us.

On the night of the morning when the intelligence reached Professor Miller and Mr. Huggins, relative to the sudden appearance of the star, they at once viewed its spectrum with the same admirable apparatus which had already conducted them to so many important discoveries connected with the physical constitution of the heavenly bodies. But what a sight was there revealed to the well-practised initiated eye of a philosopher! There lay before them the evidence which suggested the atmosphere of a star, a sun, a world, *on fire*.



SPECTRUM OF LIGHT OF BURNING WORLD.

The evidence was this: the instrument revealed *two spectra*. One of them was the usual species of spectrum, viz. a spectrum interrupted, as the solar spectrum is, by numerous *dark* lines. This indicated for the star an incandescent solid or liquid nucleus, surrounded by an atmosphere containing the vapour of sodium, and it may be iron, or magnesium, or various other elements which are found upon this our earth.

Besides this spectrum there was another, and that other full of a remarkable significance. It consisted of *four* *bright lines*, and from their relative position two of them appeared to arise from INCANDESCENT HYDROGEN.

Then, to test this appearance, they produced a spectrum of incandescent hydrogen, and the identity was absolute.

Thus the sudden outburst of light in this star, or at all events the light of the star, was in great part at least owing to *hydrogen*. In other words, it was the atmosphere of that world on fire.

Now is it possible to make a guess as to the cause of this wonderful outburst of light and heat ?

Remember, first, that the star is not a new one. It is in the catalogue of M. Argelander, and is there marked as a star of between the ninth and tenth magnitude—just the feeble brilliancy to which it has now sunk. If this star be like others, it is a sun, with worlds circling round it.

Now it is the settled opinion of some cautious philosophers that in the lapse of ages, that is, after the lapse of many millions of years—we do not say *millions of* millions of years—our own sun will have lost the greater part of its heat and light, and, like a fire, it will burn low and need more fuel. Our earth and its satellite will then approach it nearer and nearer, and ultimately rush into the great darkened luminary ; then utter indeed will be the ruin, and vast the outburst of light from the crash thereof.

Now it *may* have been that this wonderful outburst of light may have arisen from the falling into it, first of a world like our own, the earth first causing the greater, and the moon next, causing the lesser outburst which succeeded.

Now one other wonderful fact about this burning world. The conflagration was first *observed* on the 12th of May, 1866; but when did it actually *occur?*

If this star is only as far away from this our world as is the nearest yet known of the stars, then the outburst must have taken place at least three years before it was visible to us. But if, as is far more probable, this star is among those more distant orbs, then the conflagration, of which the first tidings have reached us only to-day, must have actually waxed and waned for its little week, not yesterday, but it may be even hundreds of years ago.

The imagination shrinks within itself at the thought how the bright light from that evanescent ephemeral outburst winged its swift way, leaping century through century, from world to world, and telling successively the tale of its glory to (it may be) creatures nobler and more intelligent than ourselves, at length reaches the little speck of our mortal abode, in its course onward we know not whither, as a letter leaves us, all finished and sealed and posted, to travel away to its distant destination in America.

THE END.

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