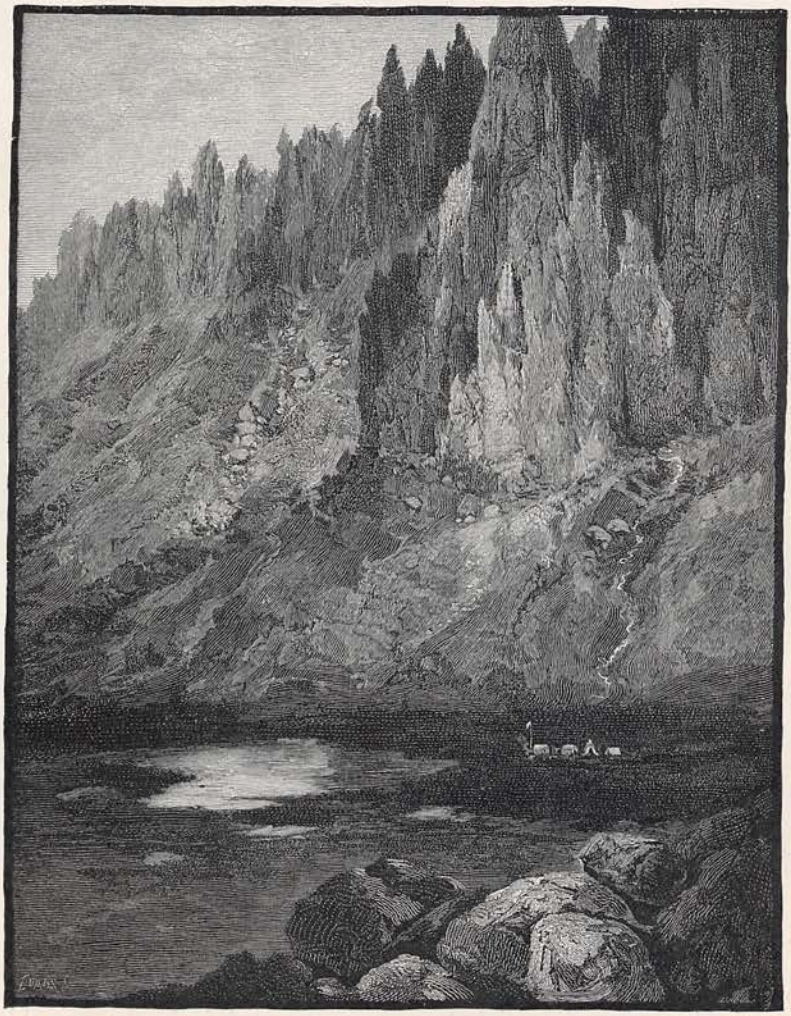
COMETS AND METEORS.

THE NEW ASTRONOMY.

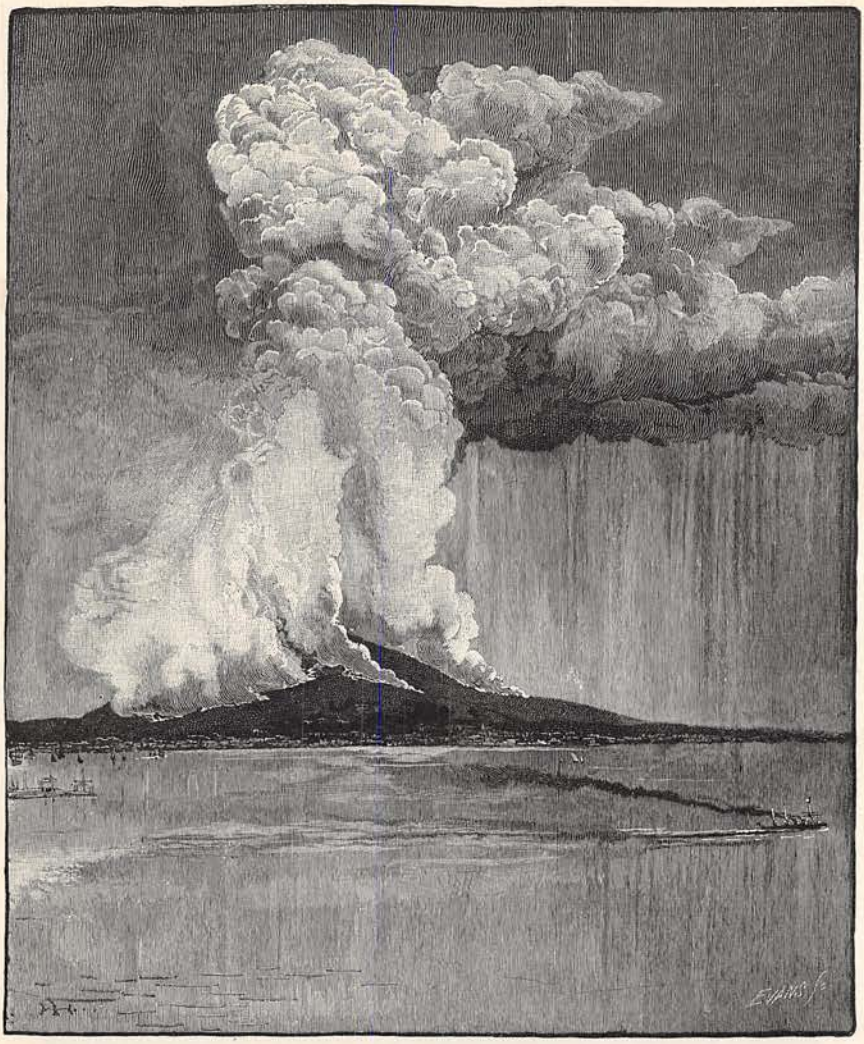


THE CAMP AT MT. WHITNEY. (FROM "PROFESSIONAL PAPERS OF THE SIGNAL SERVICE," VOL. XV.)

WHAT is truth? What is fact, and what is fancy, even with regard to solid visible things that we may see and handle?

Among the many superstitions of the early world, and credulous fancies of the middle ages, was the belief that great stones sometimes fell down out of heaven on to the earth.

Pliny has a story of such a black stone, big enough to load a chariot; the Mussulman still adores one at Mecca; and a mediæval emperor of Germany had a sword which was said to have been forged from one of these bolts shot out of the blue. But, with the revival of learning, people came to know better! That stones should fall down from the sky was clearly, they thought, an absurdity; indeed, according to the learned opinion of that time, one would hardly ask a better instance of the difference between the realities which science recognized and the absurdities



VESUVIUS DURING AN ERUPTION.

which it condemned than the fancy that such a thing could be. So at least the matter looked to the philosophers of the last century, who treated it much as they might treat certain alleged mental phenomena, for instance, if they were alive to-day, and at first refused to take any notice of these stories, when from time to time they still came to hand. When induced to give the matter consideration, they observed that all the conditions for scientific observation were violated by these bodies, since the wonder always happened at some far-off place, or at some past time, and (suspicious circumstance!) the stones only fell in the presence of ignorant and unscientific witnesses, and never when scientific men were at hand to examine the facts. That there were many worthy, if ignorant, men who asserted that they had seen such stones fall, seen them with their very eyes, and held them in their own hands, was accounted for by the general love of the marvelous and by the ignorance of the common mind, unlearned in the conditions of scientific observation, and unguided by the great principle of the uniformity of the laws of nature. Such a tone, of course, cannot be heard among us who never hastily pronounce anything a departure from the laws of nature, while uncertain that these can be separated from the laws of the fallible human mind, in which alone nature is seen. But in the last century philosophers had not yet become humble, or scientific men diffident of the absoluteness of their own knowledge, and so it seemed that no amount of evidence was enough to

gain an impartial hearing in the face of the settled belief that the atmosphere extended only a few miles above the earth's surface, and that the region beyond, whence alone such things could come, was an absolute void extending to the nearest planet.

It used to be supposed that we were absolutely isolated, not only from the stars but from other planets, by vast empty spaces extending from world to world — regions altogether vacant except for some vagrant comet; but of late years we are growing to have new ideas on this subject, and not only to consider space as far from void or tenantless, but to admit, as a possibility at least, that there is a sort of continuity between our very earth's surface, the air above it, and all which lies beyond the blue overarching dome of our own sky. Our knowledge of the physical nature of the universe without has chiefly come from what the spectroscope, overleaping the space between us and the stars, has taught us of them; as a telegram might report to us the existence of a race across the ocean, without telling anything of what lay between. It would be a novel path to the stars, and to the intermediate regions whence these once mythical stones are now actually believed to come, if we could take the reader to them by a route which enabled us to note each step of a continuous journey from the earth's surface out into the unknown; but if we undertake to start upon it, he will understand that we must almost at the outset leave the ground of comparative certainty on which we have hitherto rested, and need to speak of things on this road which are still but probabilities, and even some which are little more than conjectures, before we get to the region of comparative certainty again, a region which, strange to say, exists far away from us, while that of doubt lies close at hand. For we may be said without exaggeration to know more about Sirius than about the atmosphere a thousand miles above the earth's surface; indeed, it would be more just to say that we are sure not only of the existence but of the elements that compose a star, though a million of times as far off as the sun, while at the near point named we are not sure of so much as that the atmosphere exists at all.

To begin our outward journey in a literal sense, we might rise from the earth's surface some miles in a balloon, when we should find our progress stayed by the rarity of the air. Below us would be a gray cloud-ocean, through which we could see here and there the green earth beneath, while above us there would still be something in the apparently empty air, for if the sun has just set it will still be *light* all round us. Something then, in a cloudless sky, still exists to reflect the rays towards us, and this something is made up of separately invisible specks of dust and vapor, but very largely of actual dust, which probably forms the nucleus of each mist-particle. That discrete matter of some kind exists here has long been recognized from the phenomena of twilight; but it is, I think, only recently that we are coming to admit that a shell of actual solid particles in the form of dust probably incloses the whole globe, up to far above the highest clouds.

In 1881 the writer had occasion to conduct a scientific expedition to the highest point in the territories of the United States, on one of the summits of the Sierra Nevadas of southern California, which rise even above the Rocky Mountains.

The illustration on page 339 represents the camp occupied by this party below the summit, where the tents, which look as if in the bottom of a valley, are yet really above the highest zone of vegetation, and at an altitude of nearly twelve thousand feet.

Still above these rise the precipices of barren rock seen in the background, their very bases far above the highest visible dust-clouds, which overspread like a sea the deserts at the mountain's foot; precipices which when scaled lift the observer into what is, perhaps, the clearest and purest air to be found in the world. It will be seen from the mere looks of the landscape that we are far away here from ordinary sources of contamination in the atmosphere. Yet even above here on the highest peak, where we felt as if standing on the roof of the continent and elevated into the great aërial currents of the globe, the telescope showed particles of dust in the air, which the geologists deemed to have probably formed part of the soil of China and to have been borne across the Pacific, but which also, as we shall see later, may owe something to the mysterious source of the phenomena already alluded to.

It is far from being indifferent to us that the dust is there, for, to mention nothing else, without it, it would be night till the sunrise, and black night again as soon as the sun's edge disappeared below the horizon. The morning and the evening twilight, which in northern latitudes increase our average time of light by some hours and add very materially to the actual days of man's life, are probably due almost wholly to particles scarcely visible in the microscope, and to the presence of such atoms, smaller than the very motes ordinarily seen in the sunbeam, which, as Mr. Aitken has shown, fill the air we breathe; so minute and remote are the causes on which the habits of life depend.

Before we can see that a part of this impalpable, invisible dust is also perhaps a link between our world and other members of the

solar system, we must ask how it gets into the atmosphere. Is it blown up from the earth, or does it fall down out of the miscalled "void" of space?

If we cast a handful of dust into the air, it will not mount far above the hand unless we set the air in motion with it, as in ascending smoke-currents, and the greatest explosions we can artificially produce hurl their finer products but a few hundred feet at most from the soil. Utterly different are the forces of nature. We have on page 340 a reproduction from a photograph of an eruption of Vesuvius —a mere toy-volcano compared to Etna or Hecla. But observe the smoke-cloud which rises high in the sunshine, looking solid as the rounded snows of an Alp, while the cities and the sea below are in the shadow. The smoke that mounts from the foreground, where the burning lava-streams are pouring over the surface and firing the woods, is of another kind from that rolling high above. *This* comes from within the mountain, and is composed of clouds of steam mingled with myriads of dust-particles from the comminuted products of the earth's interior, and we can see ourselves that it is borne away on a level, miles high in the upper air.

But what is this to the eruption of Sumbawa or Krakatao? The latter occurred in 1883, and it will be remembered that the air-wave started by the explosion was felt around the globe, and that, probably owing to the dust and water-vapor blown into the atmosphere, the sunsets even in America became of that extraordinary crimson we all remember three years ago, and coincidently, that dim, reddish halo made its appearance about the sun the world over, which is hardly yet gone. Very careful estimates of the amount of ashes ejected have been made; and though most of the heavier particles are known to have fallen into the sea within a few miles, a certain portion—the lightest—was probably carried by the explosion far above the lower strata of the atmosphere, to descend so slowly that some of it may still be there. Of this lighter class the most careful estimates must be vague, but according to the report of the official investigation by the Dutch government that which remained floating is something enormous. An idea of its amount may be gained by supposing these impalpable and invisible particles to condense again from the upper sky, and to pour down on the highest edifice in the world, the Washington Monument. If the dust were allowed to spread out on all sides, till the pyramidal slope was so flat as to be permanent, the capstone of the monument would not only be buried before the supply was exhausted, but buried as far below the surface as that pinnacle is now above.

Of the explosive suddenness with which the mass was hurled, we can judge something (comparing small things with great) by the explosion of dynamite.

It happened once that the writer was standing by a car in which some railway porters were lifting boxes. At that moment came an almost indescribable sound, for it was literally stunning, though close and sharp as the crack of a whip in one's hand, and yet louder than the nearest thunder-clap. The men leaped from the car, thinking that one of the boxes had exploded between them; but the boxes were intact, and we saw what seemed a pillar of dust rising above the roof of the station, hundreds of yards away. When we hurried through the building, we found nothing on the other side but a bare plain, extending over a mile, and beyond this the actual scene of the explosion that had seemed to be at our feet. There had been there, a few minutes before, extensive buildings and shops belonging to the railroad, and sidings on which cars were standing, two of which, loaded with dynamite, had exploded.

Where they had been was a crater-like depression in the earth, some rods in diameter; the nearest buildings, great solid structures of brick and stone, had vanished, and the more distant wooden ones and the remoter lines of freight-cars on the side-tracks presented a curious sight, for they were not shattered so much as bent and leaning every way, as though they had been built of pasteboard, like card-houses, and had half yielded to some gigantic puff of breath. All that the explosion had shot skyward had settled to earth or blown away before we got in sight of the scene, which was just as quiet as it had been a minute before. It was like one of the changes of a dream.

Now it is of some concern to us to know that the earth holds within itself similar forces, on an incomparably greater scale. For instance, the explosion which occurred at Krakatao, at five minutes past ten, on the 27th of August, 1883, according to official evidence, was heard at a distance of 1800 miles, and the puff of its air-wave injured dwellings two hundred miles distant, and, we repeat, carried into the highest regions of the atmosphere and around the world matter which it is at least possible still affects the aspect of the sun today from New York or Chicago.

Do not the great flames which we have seen shot out from the sun at the rate of hundreds of miles a second, the immense and sudden perturbations in the atmosphere of Jupiter, and the scarred surface of the moon, seem to

be evidences of analogous phenomena, common to the whole solar system, not wholly unconnected with those of earthquakes, and which we can still study in the active volcanoes of the earth?

If the explosion of gunpowder can hurl a cannon-shot three or four miles into the air, how far might the explosion of Krakatao cast its fragments? At first we might think there must be some proportionality between the volume of the explosion and the distance, but this is not necessarily so. Apart from the resistance of the air, it is a question of the velocity with which the thing is shot upward, rather than the size of the gun, or the size of the thing itself, and with a sufficient velocity the projectile would never fall back again. "What goes up must come down" is, like most popular maxims, true only within the limits of ordinary experience; and even were there nothing else in the universe to attract it, and though the earth's attraction extend to infinity, so that the body would never escape from it, it is yet quite certain that it would, with a certain initial velocity (very moderate in comparison with that of the planet itself), go up and *never* come back; while under other and possible conditions it might voyage out into space on a comet-like orbit, and be brought back to the earth, perhaps in after ages, when the original explosion had passed out of memory or tradition. But because all this is possible, it does not follow that it is necessarily true; and if the reader ask why he should then be invited to consider such suppositions at all, we repeat that in our journey outward, before we come to the stars, of which we know something, we pass through a region of which we know almost nothing; and this region, which is peopled by the subjects of conjecture, is the scene, if not the source, of the marvel of the falling stones, concerning which the last century was so incredulous, but for which we can, aided by what has just been said, now see at least a possible cause, and to which we now return.

Stories of falling stones, then, kept arising from time to time during the last century as they had always done, and philosophers kept on disbelieving them as they had always done, till an event occurred which suddenly changed scientific opinion to compulsory belief.

On the 26th of April, 1803, there fell, not in some far-off part of the world, but in France, not one alone, but many thousand stones, over an area of some miles, accompanied with noises like the discharge of artillery. A committee of scientific men visited the spot on the part of the French Institute, and brought back, not only the testimony of scores of witnesses or auditors, but the stones themselves. Soon after stones fell in Connecticut, and here and elsewhere, as soon as men were prepared to believe, they found evidence multiplied; and such falls, it is now admitted, though rare in any single district, are of what may be called frequent occurrence as regards the world at large; for, taking land and sea together, the annual stone-falls are probably to be counted by hundreds.

It was early noticed that these stones consisted either of a peculiar alloy of iron, or of minerals of volcanic origin, or both, and the first hypothesis was that they had just been shot out from terrestrial volcanoes. As they were, however, found, as in the case of the Connecticut meteorite, thousands of miles from any active volcanoes, and were seen to fall, not vertically down, but as if shot horizontally overhead, this view was abandoned. Next the idea was suggested that they were coming from volcanoes in the moon; and though this had little to recommend it, it was adopted in default of a better, and entertained down to a comparatively very recent period. These stones are now collected in museums, where any one may see them, and are to be had of the dealers in such articles by any who wish to buy them. They are coming to have such a considerable money value that, in one case at least, a lawsuit has been instituted for their possession between the finder, who had picked the stones up on ground leased to him, and claimed them under the tenant's right to wild game, and his landlord, who thought they were his as part of the real estate.

Leaving the decision of this novel law-point to the lawyers, let us notice some facts now well established.

The fall is usually preceded by a thundering sound, sometimes followed or accompanied by a peculiar sound described as like that of a flock of ducks rising from the water. The principal sound is often, however, far louder than any thunder, and sometimes of stunning violence. At night this is accompanied by a blaze of lightning-like suddenness and whiteness, and the stones commonly do not fall vertically, but as if shot from a cannon at long range. They are usually burning hot, but, in at least one authenticated instance, one was so intensely cold that it could not be handled. They are of all sizes, from tons to ounces, comparatively few, however, exceeding a hundredweight, and they are oftenest of a rounded form, or looking like pieces of what was originally round, and usually wholly or partly covered with a glaze formed of the fused substance itself. If we slowly heat a lump of loaf sugar all through, it will form a pasty mass, while we may also hold it without inconvenience in our fingers to the gas-flame a few sec-

onds, when it will be melted only on the side next the sudden heat, and rounded by the melting. The sharp contrast of the melted and the rough side is something like that of the meteorites; and just as the sugar does not burn the hand, though close to where it is brought suddenly to a melting heat, a mass of ironstone may be suddenly heated on the surface, while it remains cold on the inside. But, however it got there, the stone undoubtedly comes from the intensely cold spaces above the upper air; and what is the source of such a heat that it is melted in the cold air, and in a few seconds?

Everybody has noticed that if we move a fan gently, the air parts before it with little effort, while, when we try to fan violently, the same air is felt to react; yet if we go on to say that if the motion is still more violent the atmosphere will resist like a solid, against which the fan, if made of iron, would break in pieces, this may seem to some an unexpected property of the "nimble" air through which we move daily. Yet this is the case, and if the motion is only so quick that the air cannot get out of the way, a body hurled against it will rise in temperature like a shot striking an armor-plate. It is all a question of speed, and that of the meteorite is known to be immense. One has been seen to fly over this country from the Mississippi to the Atlantic in an inappreciably short time, probably in less than two minutes; and though at a presumable height of over fifty miles, the velocity with which it shot by gave every one the impression that it went just above his head, and some witnesses of the unexpected apparition looked the next day to see if it had struck their chimneys. The heat developed by arrested motion in the case of a mass of iron moving twenty miles a second can be calculated, and is found to be much more than enough, not only to melt it, but to turn it into vapor; though what probably does happen is, according to Professor Newton, that the melted surface-portions are wiped away by the pressure of the air and volatilized to form the luminous train, the interior remaining cold, until the difference of temperature causes a fracture, when the stone breaks and pieces fall — some of them at red-hot heat, some of them possibly at the temperature of outer space, or far below that of freezing mercury.

Where do these stones come from? What made them? The answer is not yet complete, but if a part of the riddle is already yielding to patience, it is worthy of note, as an instance of the connection of the sciences, that the first help to the solution of this astronomical enigma came from the chemists and the geologists.

The earliest step in the study, which has now been going on for many years, was to analyze the meteorite, and the first result was that it contained no elements not found on this planet. The next was that, though none of these elements were unknown, they were not combined as we see them in the minerals we dig from the earth. Next it was found that the combinations, if unfamiliar at the earth's surface and nowhere reproduced exactly, were at least very like such as existed down beneath it, in lower strata, as far as we can judge by specimens of the earth's interior cast up from volcanoes. Later, a resemblance was recognized in the elements of the meteorites to those found by the spectroscope in shooting stars, though the spectroscopic observation of the latter is too difficult to have even yet proceeded very far. And now, within the last few years, we seem to be coming near to a surprising solution.

It has now been shown that meteoric stones sometimes contain pieces of essentially different rocks fused together, and pieces of detritus — the wearing down of older rocks. Thus, as we know that sandstone is made of compacted sand, and sand itself was in some still earlier time part of rocks worn down by friction — when it is shown, as it has been by M. Meunier, that a sandstone with threads of copper in it (like some of our Lake Superior formations) has come to us in a meteorite, his conclusion that these stones may be part of some old world is one that, however startling, we cannot refuse at least to consider. According to this view, there may have been a considerable planet near the earth, which, having reached the last stage of planetary existence shown in the case of our present moon, went one step further — went, that is, out of existence altogether, by literal breaking up and final disappearance. We have seen the actual moon scarred and torn in every direction, and are asked to admit the possibility that a continuance of the process on a similar body has broken it up into the fragments that come to us. We do not say that this is the case, but that (as regards the origin of some of the meteorites at least) we cannot at present disprove it. We may at any rate present to the novelist seeking a new *motif* that of a meteorite bringing to us the story of a lost race, in some fragment of art or architecture of its lost world.

We are not driven to this world-shattering hypothesis by the absence of others, for we may admit these to be fragments of a larger body without necessarily concluding that it was a world like ours, or, even if it were, that the world which sent them to us is destroyed. In view of what we have been learning of the tremendous explosive forces we see in action on the sun and probably on other planets, and

even in terrestrial volcanoes to-day, it is certainly conceivable that some of these stones may have been ejected by some such process from any sun, or star, or world we see. The reader is already prepared for the suggestion that part of them may be the product of terrestrial volcanoes in early epochs, when our planet was yet glowing sunlike with its proper heat, and the forces of nature were more active; and that these errant children of mother earth's youth, after circulating in lengthened orbits, are coming back to her in her age.

Do not let us, however, forget that these are mostly speculations only, and perhaps the part of wisdom is not to speculate at all till we learn more facts; but are not the facts themselves as extraordinary as any invention of fancy?

Although it is true that the existence of the connection between shooting stars and meteorites lacks some links in the chain of proof, we may very safely consider them together; and if we wish to know what the New Astronomy has done for us in this field, we should take up some treatise on astronomy of the last century. We turn in one to the subject of falling stars, and find that "This species of Star is only a light Exhalation, almost wholly sulphurous, which is inflamed in the free Air much after the same manner as Thunder in a Cloud by the blowing of the Winds." That the present opinion is different we shall shortly notice.

All of us have seen shooting stars, and they are indeed something probably as old as this world, and have left their record in mythology as well as in history. According to Moslem tradition, the evil genii are accustomed to fly at night up to the confines of heaven in order to overhear the conversation of the angels, and the shooting stars are the fiery arrows hurled by the latter at their lurking foes, with so good an aim that we are told that for every falling star we may be sure that there is one spirit of evil the less in the world. The scientific view of them, however, if not so consolatory, is perhaps more instructive, and we shall here give most attention to the latter.

To begin with, there have been observed in history certain times when shooting stars were unusually numerous. The night when King Ibrahim Ben Ahmed died, in October, 902, was noted by the Arabians as remarkable in this way, and it has frequently been observed since that, though we can always see some of these meteors nightly, there are at intervals very special displays of them. The most notable modern one was on November 13th, 1833, and this was visible over much of the North American continent, forming a spectacle of terrifying grandeur.

An eye-witness in South Carolina wrote: "I was suddenly awakened by the most distressing cries that ever fell on my ears. Shrieks of horror and cries for mercy I could hear from most of the negroes of the three plantations, amounting in all to about 600 or 800. While earnestly listening for the cause I heard a faint voice near the door, calling my name. I arose, and, taking my sword, stood at the door. At this moment I heard the same voice still beseeching me to rise, and saying, 'O my God, the world is on fire!' I then opened the door, and it is difficult to say which excited me the most—the awfulness of the scene, or the distressed cries of the negroes. Upwards of one hundred lay prostrate on the ground—some speechless and some with the bitterest cries, but with their hands raised, imploring God to save the world and them. The scene was truly awful; for never did rain fall much thicker than the meteors fell towards the earth; east, west, north, and south, it was the same."

The illustration on page 349 does not exaggerate the number of the fiery flashes at such a time, though the zigzag course which is observed in some is hardly so common as it here appears.

When it was noted that the same date, November 13th, had been distinguished by star-showers in 1831 and 1832, and that the great shower observed by Humboldt in 1799 was on this day, the phenomenon was traced back and found to present itself about every thirty-three years, the tendency being to a little delay on each return; so that Professor Newton and others have found it possible with this clue to discover in early Arabic and other mediæval chronicles and in later writers descriptions which, fitted together, make a tolerably continuous record of this thirty-three-year shower, beginning with that of King Ibrahim already alluded to. The shower appeared again in November, 1867 and 1868, with less display, but with sufficient brilliance to make the writer well remember the watch through the night, and the count of the flying stars, his most lively recollection being of their occasional colors, which in exceptional cases ranged from full crimson to a vivid green. The count on this night was very great, but the number which enter the earth's atmosphere even ordinarily is most surprising; for, though any single observer may note only a few in his own horizon, yet, taking the world over, at least ten millions appear every night, and on these special occasions very many more. This November shower comes always from a particular quarter of the sky, that occupied by the constellation Leo, but there are others, such as that of August 10th (which is annual), in which the "stars" seem to be shot

at us from the constellation Perseus: and each of the numerous groups of star-showers is now known by the name of the constellation whence it seems to come, so that we have *Perseids* on August 10th, *Geminids* on December 12th, *Lyrids* April 20th, and so on.

The great November shower, which is coming once more in this century, and which every reader may hope to see towards 1899, is of particular interest to us as the first whose movements were subjected to analysis, for it has been shown by the labors of Professor Newton, of Yale, and Adams, of Cambridge, that these shooting stars are bodies moving around the sun in an orbit which is completed in about thirty-three years. It is quite certain, too, that they are not exhalations from the earth's atmosphere, but little solids, invisible till they shine out by the light produced by their own fusion. Each, then, moves on its own track, but the general direction of all the tracks concurs; and though some of them may conceivably be solidified gases, we should think of them not as gaseous in form, but as solid shot, of the average size of something like a cherry, or perhaps even of a cherry-stone, yet each an independent planetoid, flying with a hundred times the speed of a rifle-bullet on its separate way as far out as the orbit of Uranus; coming back three times in a century to about the earth's distance from the sun, and repeating this march forever, unless it happen to strike the atmosphere of the earth itself, when there comes a sudden flash of fire from the contact, and the distinct existence of the little body, which may have lasted for hundreds of thousands of years, is ended in a second.

If the reader will admit so rough a simile, we may compare such a flight of these bodies to a thin swarm of swift-flying birds — thin, but yet immensely long, so as to be, in spite of the rapid motion, several years in passing a given point, and whose line of flight is cut across by us on the 13th of November, when the earth passes through it. We are only there on that day, and can only see it then; but the swarm is years in all getting by, and so we may pass into successive portions of it on the anniversary of the same day for years to come. The stars appear to shoot from Leo, only because that constellation is in the line of their flight when we look up to it, just as an interminable train of parallel flying birds would appear to come from some definite point on the horizon.

We can often see the flashes of meteors at over a hundred miles, and though at times they may seem to come thick as flakes of falling snow, it is probable, according to Professor Newton, that even in a "shower" each tiny planetoid is more than ten miles from its nearest neighbor, while on the average it is reckoned that we may consider that each little body, though possibly no larger than a pea, is over two hundred miles from its neighbor, or that to each such grain there is nearly 10,000,000 cubic miles of void space. Their velocity as compounded with that of the earth is enormous, sometimes forty to fifty miles per second (according to a recent but unproved theory of Mr. Denning's, it would be much greater), and it is this enormous rate of progress that affords the semblance of an abundant fall of rain, notwithstanding the distance at which one drop follows another. It is only from their light that we are able to form a rough estimate of their average size, which is, as we have seen, extremely small, but, from their great number, the total weight they add to the earth daily may possibly be a hundred tons, probably not very much more. As they are as a rule entirely dissipated in the upper air, often at a height of from fifty to seventy miles, it follows that many tons of the finest pulverized and gaseous matter are shot into the earth's atmosphere every twenty-four hours from outer space, so that here is an independent and constant supply of dust, which we may expect to find coming down from far above the highest clouds.

Now, when the reader sees the flash of a shooting star, he may, if he please, think of the way the imagination of the East accounts for it, or he may look at what science has given him instead. In the latter case he will know that a light which flashed and faded almost together came from some strange little entity which had been traversing cold and vacant space for untold years, to perish in a moment of more than fiery heat; an enigma whose whole secret is unknown, but of which, during that instant flash, the spectroscope caught a part, and found evidence of the identity of some of its constituents with those of the observer's own body.

Of comets, the Old Astronomy knew that they came to the sun from great distances in all directions, and in calculable orbits; but as to *what* they were, this, even in the childhood of those of us who are middle-aged, was as little known as to the centuries during which they still from their horrid heads shook pestilence and war. We do not know even now by any means exactly what they are, for enough yet remains to be learned about them still to give their whole study the attraction which belongs to the unknown; and yet we learn so much, and in a way which to our grandfathers would have been so unexpected, connecting together the comet, the shooting star, and the meteorite, that the astronomer who

perhaps speaks with most authority about these to-day was able not long ago, in beginning a lecture, to state that he held in his hand what had been a part of a comet; and what he held was, not something half vaporous or gaseous, as we might suppose from our old associations, but a curious stone like this on page 350, which, with others, had fallen from the sky in Iowa, a flashing prodigy, to the terror of barking dogs, shying horses, and fearful men, followed by clouds of smoke and vapor, and explosions that shook the houses like an earthquake, and "hollow bellowings and rattling sounds, mingled with clang and clash and roar," as an auditor described it. It is only a fragment of a larger stone which may have weighed tons. It looks inoffensive enough now, and its appearance affords no hint of the commotion it caused in a peaceable neighborhood only ten years ago. But what, it may be asked, is the connection between such things and comets?

To answer this, let us recall the statement that the orbit of the November meteor swarm has been computed, which means that those flying bodies have been found to come only from one particular quarter out of all possible quarters, at one particular angle out of all possible angles, at one particular velocity out of all possible velocities, and so on, so that the chances are endless against mere accident's producing another body which agreed in all these particulars, and others beside. Now, in 1867 the remarkable fact was established that a comet seen in the previous year (Comet 1, 1866) had the same orbit as the meteoroids, which implies, as we have just seen, that the comet and the meteors were in some way closely related.

The paths of the August meteors and of the Lyrids also have both been found to agree closely with those of known comets, and there is other evidence which not only connects the comets and the shooting stars, and makes it probable that the latter are due to some disintegration of the former, but even looks as though the process were still going on. And now with this in mind we may, perhaps, look at these drawings with more interest.

We have all seen a comet, and we have all felt, perhaps, something of the awe which is called up by the thought of its immensity and its rush through space like a runaway star. Its head is commonly like a small luminous point, from which usually grows as it approaches the sun a relatively enormous brush or tail of pale light, which has sometimes been seen to stretch across the whole sky from zenith to horizon. It is useless to look only along the ecliptic road for a comet's coming; rather may we expect to see it rushing down from above, or up from below, sometimes with a speed which is possibly greater than it could get from any fall — not so much, that is, the speed of a body merely dropping towards the sun by its weight, as that of a missile hurled into the orderly solar system from some unknown source without, and also associated with some unknown power; for while it is doubtful whether gravity is sufficient to account for the velocity of all comets, it seems certain that gravity can in no way explain some of the phenomena of their tails.

Thousands of comets have been seen since the Christian era, and the orbits of hundreds have been calculated since the time of Newton. Though they may describe any conic section, and though most orbits are spoken of as parabolas, this is rather a device for the analyst's convenience than the exact representation of fact. Without introducing more technical language, it will be enough to say here that we learn in other cases from the form of the orbit whether the body is drawn essentially by the sun's gravity, or whether it has been thrown into the system by some power beyond the sun's control, to pass away again, out of that control, never to return. It must be admitted, however, that though several orbits are so classed, there is not any one known to be beyond doubt of this latter kind, while we are certain that many comets, if not all, are erratic members of the solar family, coming back again after their excursions, at regular, though perhaps enormous, intervals.

But what we have just been saying belongs rather to the province of the Old Astronomy than the New, which concerns itself more with the nature and appearance of the heavenly bodies than the paths they travel on. Perhaps the best way for us to look at comets will be to confine our attention at first to some single one, and to follow it from its earliest appearance to its last, by the aid of pictures, and thus to study, as it were, the species in the individual. The difficulty will be one which arises from the exquisitely faint and diaphanous appearance of the original, which no ordinary care can possibly render, though here the reader has had done for him all that the wood-engraver can do.

We will take as the subject of our illustration the beautiful comet which those of us who are middle-aged can remember seeing in 1858, and which is called Donati's from the name of its discoverer. We choose this one because it is the subject of an admirable monograph by Professor Bond of the Harvard College Observatory, from which our engravings have, by permission, been made.

Let us take the history of this comet, then, as a general type of others; and to begin at

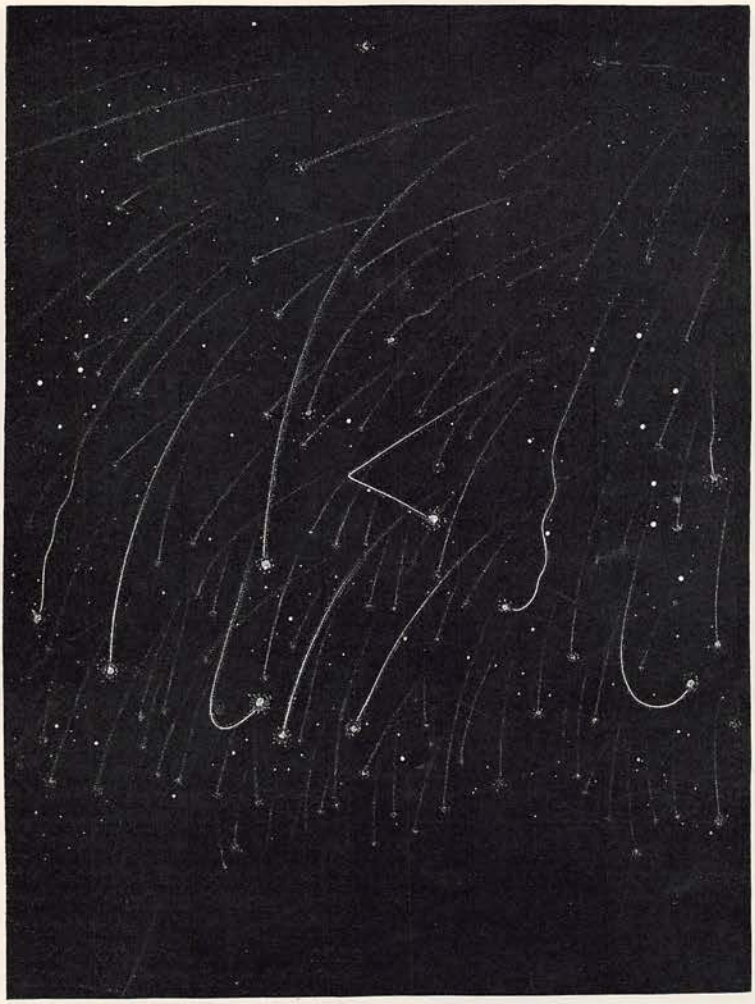
the beginning, we must make the very essential admission that the origin of the comet's life is unknown to us. Where it was born or how it was launched on its eccentric path we can only guess, but do not know, and how long it has been traversing it we can only tell later. On the second of June, 1858, this one was discovered in the way most comets are found, that is, by a comet-hunter, who detected it as a telescopic speck long before it became visible to the naked eye, or put forth the tail which was destined to grow into the beautiful object many of us can remember seeing. For over a century now there has been probably no year in which the heavens have not been thus searched by a class of observers who make comet-hunting a specialty.

The father of this very valuable class of observers appears to have been Messier, a Frenchman of the last century and of the purest type of the comet-hunters, endowed by nature with the instinct for their search that a terrier has for rats. In that grave book, Delambre's "History of Astronomy," as we plod along its dry statements and through its long equations, we find, unexpected as a joke in a table of logarithms, the following piece of human nature (quoted from Messier's contemporary, La Harpe):

"He [Messier] has passed his life in nosing out the tracks of comets. He is a very worthy man, with the simplicity of a baby. Some years ago he lost his wife, and his attention to her prevented him from discovering a comet he was on the search for, and which Montaigne of Limoges got away from him. He was in despair. When he was condoled with on the loss he had met, he replied, with his head full of the comet, 'Oh, dear! To think that when I had discovered twelve, this Montaigne should have got my thirteenth,' and his eyes filled with tears, till, remembering what it was he ought to be weeping for, he moaned, 'Oh, my poor wife!' but went on crying for his comet."

Messier's scientific posterity has greatly multiplied, and it is rare now for a comet to be seen by the naked eye before it has been caught by the telescope of one of these assiduous searchers. Donati had, as we see, observed his some months before it became generally visible, and accordingly the engraving on page 350 shows it as it appeared on the evening of September 16th, 1858, when the tail was already formed, and, though small, was distinct to the naked eye, near the stars of the Great Bear. The reader will easily recognize in the plate the familiar "dipper," as the American child calls it, where the leading stars are put down with care, so that he may, if he please, identify them by comparison with the originals in the sky, even to the little companion to Mizar (the second in the handle of the "dipper," and which the Arabs say is the lost Pleiad). We would suggest that he should note both the length of the tail on this evening as compared with the space between any two stars of the "dipper" (for instance, the two right-hand ones called the "pointers") and its distance from them, and then turn to page 352, where we have the same comet as seen a little over a fortnight later, on October 3d. Look first at its new place among the stars. The "dipper" is still in view, but the comet has drifted away from it toward the left and into other constellations. The large star close to the left margin of the plate, with three little stars below and to the right, is Arcturus; and the western stars of the Northern Crown are just seen higher up. Fortunately the "pointers" with which we compared the comet on September 16th are still here, and we can see for ourselves how it has not only shifted but grown. The tail is three times as long as before. It is rimmed with light on its upper edge, and fades away so gradually below that one can hardly say where it ends. But,—wonderful and incomprehensible feature!—shot out from the head, almost as straight as a ray of light itself, but fainter than the moonbeam, now appears an extraordinary addition, a sort of spur, which we can hardly call a new tail, it is so unlike the old one, but which appears to have been darted out into space as if by some mysterious force acting through the head itself. What the spur is, what the tail is, even what the nucleus is, we cannot be said really to know even to-day; but of the tail and of the nucleus or speck in the very head of the comet (too small to be visible in the engraving), we may say that the hairy tail *(comes)* gives the comet its name, and *is* the comet to popular apprehension, but that it is probably the smallest part of the whole mass, while the little shining head, which to the telescope presents a still smaller speck called the nucleus, contains, it now seems probable, the only element of possible danger to the earth.

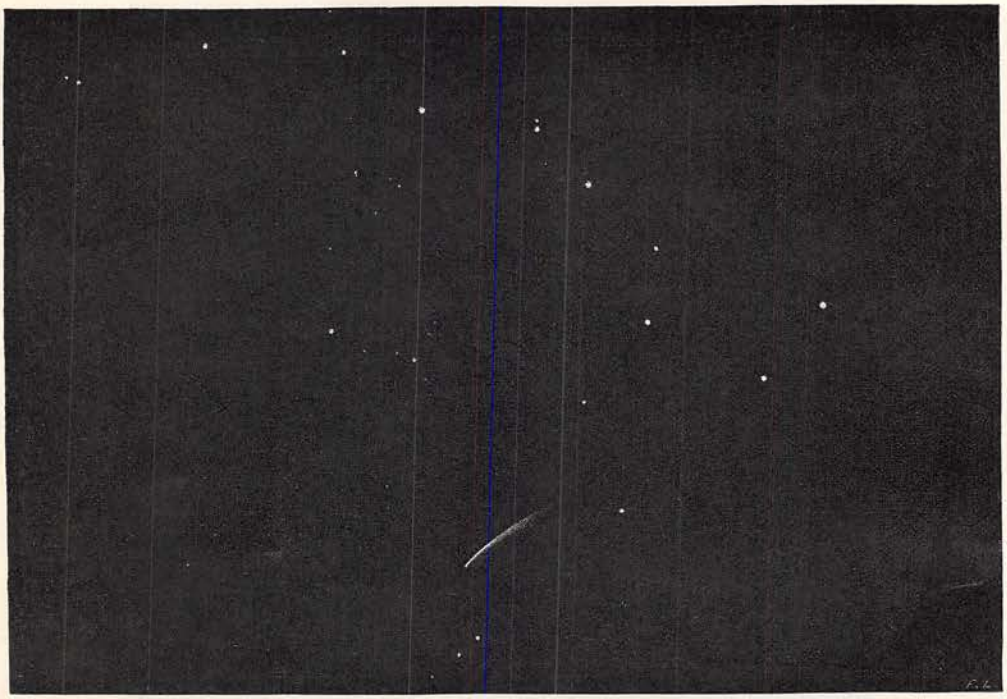
While admitting our lack of absolute knowledge, we may, if we agree that meteorites were once part of a comet, say that it now seems probable that the nucleus is a hard, stone-like mass, or collection of such masses, which comes from "space" (*i.e.*, from we don't know how far) to the vicinity of the sun, and there is broken by the heat as a stone in a hot fire. (Sir Isaac Newton calculates, in an often quoted passage of the Principia, that the heat which the comet of 1680 was subjected to in its passage by the sun was 2000 times that of red-hot iron.) We have seen the way in which meteoric stones actually do crack in pieces with heat in our own atmosphere, partly, perhaps, from the expansion of the



METEORS OBSERVED NOVEMBER 13TH–14TH, 1868, BETWEEN MIDNIGHT AND FIVE O'CLOCK, A. M.
(PUBLISHED BY PERMISSION OF CHARLES SCRIBNER'S SONS.)

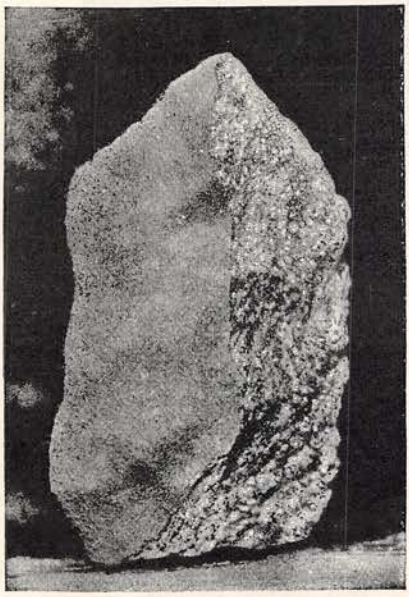
gases the stone contains, and it seems entirely reasonable to suppose that they may do so from the heat of the sun, and that the escaped gases may contribute something toward the formation of the tail, which is always turned away from the sun, and which always grows larger as that is approached, and smaller as it is receded from. However this may be, there is no doubt that the original solid which we here suppose may form the nucleus is capable of mischief, for it is asserted that it often passes the earth's orbit with a velocity of as much as one hundred times that of a cannon-ball; that is, with ten thousand times the destructive capacity of a ball of the same weight shot from a cannon.

One week later, October 9th, the comet had passed over Arcturus with a motion toward our left into a new region of the sky, leaving Arcturus, which we can recognize with the upper one of its three little companions, on the right. Above it is the whole sickle of the Northern Crown, and over these stars the extremity of the now lengthened tail was seen to spread, but with so thin a veil that no art of the engraver can here adequately represent its faintness. The tail then, as seen in the sky, was now nearly twice its former size, though for the reason mentioned it may not appear so in our picture. It should be understood, too, that even the brightest parts of the original were far fainter than they seem here in comparison with the stars, which in the sky are brilliant points of light, which the engraver can only represent by dots of the whiteness of the paper. This being observed, it will be better understood that in the sky itself the faintest stars were viewed ap-



COMET OF DONATI, SEPTEMBER 16TH, 1858.*

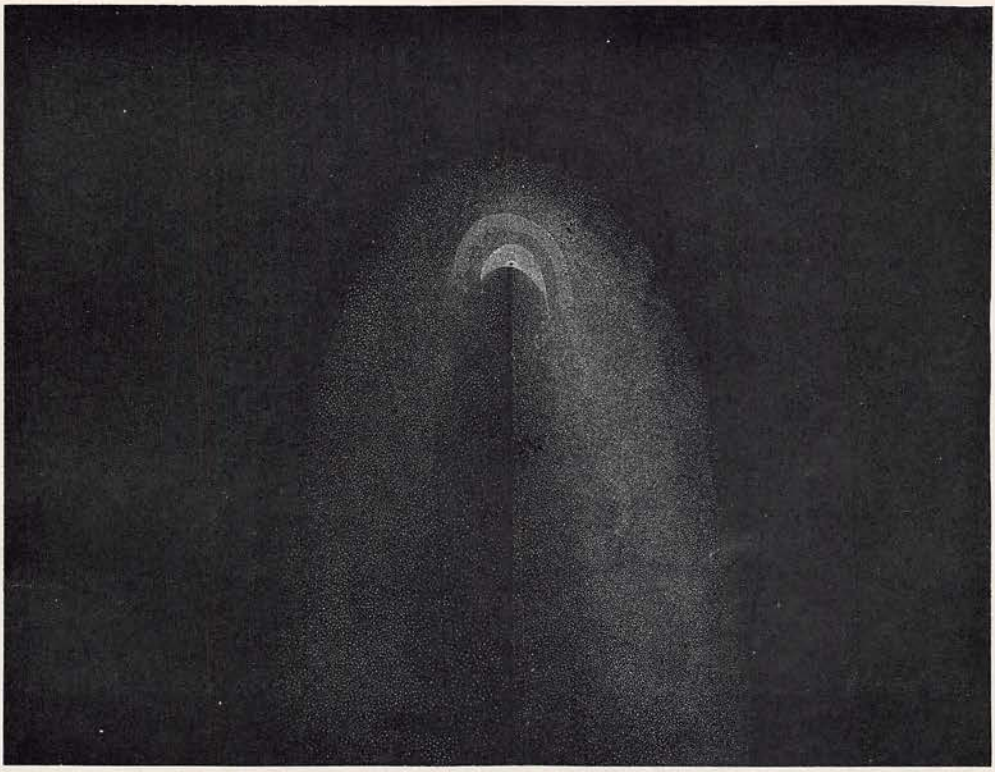
parently undimmed through the brighter parts of the comet, while we can but faintly trace here another most faint but curious feature, a division of the tail into faint cross-bands like auroral streamers, giving a look as if it were yielding to a wind, which folded it into faint ridges like those which may be seen in the smoke of a steamer as it lags far behind the vessel. In fact, when we speak of "the" tail it must be understood, as M. Faye reminds us, to be in the same sense that we speak of the plume of smoke that accompanies an ocean steamer, without meaning that it is the same thing which we are watching from night to night, more than we do that the same smoke-particles accompany the steamer as it moves across the Atlantic. In both cases the form alone probably remains; the thing itself is being incessantly dissipated and renewed. There is no air here, and yet some of these appearances in the original almost suggest the idea of medium inappreciably thin as compared with the head of the comet, but whose resistance is seen in the more unsubstantial tail, as that is drawn through it and bent backward, as if by a wind blowing toward the celestial pole.



A PART OF A COMET.

The most notable feature, however, is the development of a second ray or spur, which has been apparently darted through millions of miles in the interval since we looked at it, and an almost imperceptible bending backward in both, as if they too felt the resistance of something in what we are accustomed to think of as an absolute and perfect void. These tails are a peculiarly mysterious feature. They are apparently shot out in a direction opposite to the sun (and consequently opposed to the

* The five wood-cuts of this comet are after steel plates in "Annals of Harvard Observatory."



COMET OF DONATI, SEPTEMBER 24TH, 1858. (TELESCOPIC VIEW OF HEAD.)

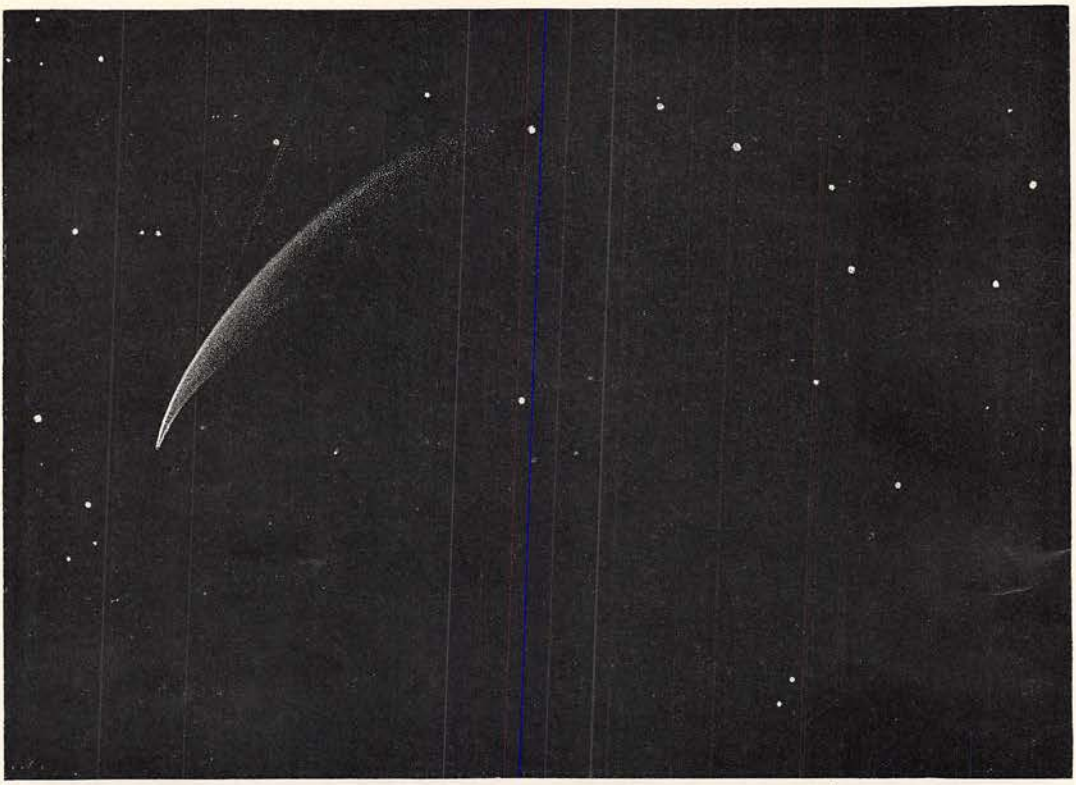
direction of gravity) at the rate of millions of miles a day.

Beyond the fact that the existence of some *repulsive* force in the sun, a "negative gravity" actually existent, not in fancy, but in fact, seems pointed at, astronomers can offer little but conjecture here; and while some conceive this force as of an electrical nature, others strenuously deny it. We ought to admit that up to the present time we really know nothing about it, except that it exists.

At this date (October 9th) the comet had made nearly its closest approach to the earth, and the general outline has been compared to that of the wing of some bird, while the actual size was so vast that even at the distance from which it was seen it filled an angle more than half of that from the zenith to the horizon.

All the preceding drawings have been from naked-eye views, but if the reader would like to look more closely he can see on page 354 one taken on the night of October 5th through the great telescope at Cambridge, Mass. We will leave this to tell its own story, only remarking that it is not possible to reproduce the phantom-like faintness of the original spur, here too distinctly seen, or indeed to indicate fairly the infinite tenuity of the tail itself. Though millions of miles thick, the faintest star is yet perceptibly undimmed by it, and in estimating the character and quantity of matter it contains, after noting that it is not self-luminous, but shines only like the moon by reflected sunlight, we may recall the acute observation of Sir Isaac Newton where he compares the brightness of a comet's tail with that of the light reflected from the particles in a sunbeam an inch or two thick, in a darkened room, and, after observing that if a little sphere of common air one inch in diameter were rarified to the degree that must obtain at only 4000 miles from the earth's surface it would fill all the regions of the planets to far beyond the orbit of Saturn, suggests the excessively small quantity of vapor that is really requisite to create this prodigious phantom.

The writer has had occasion for many years to make a special study of the reflection of light from the sky, and if such studies may authorize him to express any opinion of his own, he would give his adhesion to the remark of Sir John Herschel, that the actual weight of matter in such a cometary tail may be conceivably only an affair of pounds or even ounces. But if this is true of the tail, it does not follow of the nucleus, just seen in this



COMET OF DONATI, OCTOBER 3D, 1858.

picture, but of which the engraving on page 351 gives a much more magnified view. It is a sketch of the head alone, taken from a telescopic view on the 24th of September. Here the direction of the comet is still toward the sun (which must be supposed to be some indefinite distance beyond the upper part of the drawing), and we see that the lucid matter appears to be first jetted up, and then forced backward on either side, as if by a wind *from* the sun, to form the tail, presenting successive crescent-shaped envelopes of decreasing brightness, which are not symmetrical, but one-sided, while sometimes the appearance is that of spurts of luminous smoke, wavering as if thrown out of particular parts of the internal nucleus "like a squib not held fast." Down the center of the tail runs a wonderfully straight black line, like a shadow cast from the nucleus. Only the nucleus itself still evades us, and even in this, the most magnified view which the most powerful telescope till lately in existence could give, remains a point.

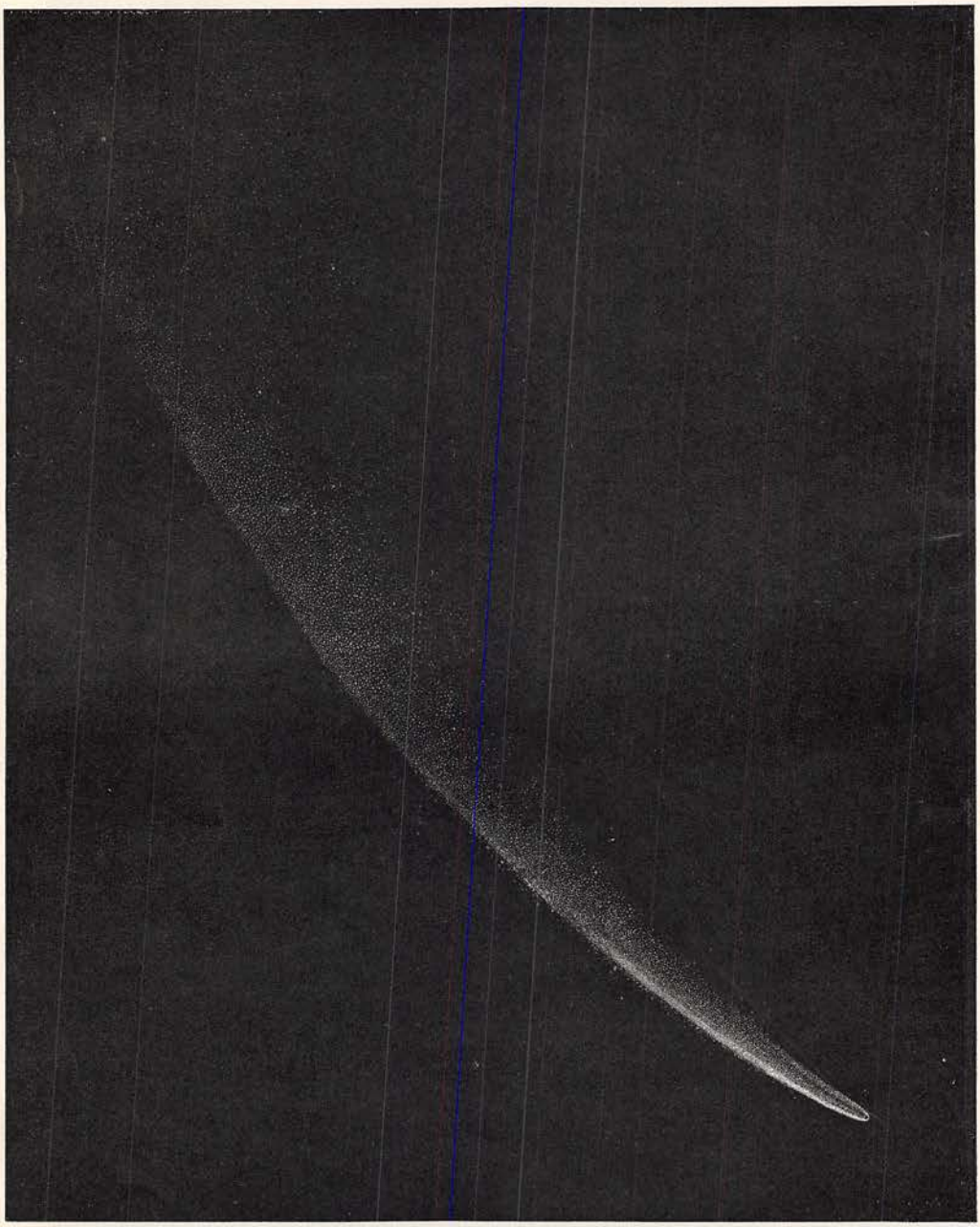
Considering the distance of the comet and the other optical conditions, this is still perfectly consistent with the possibility that it may have an actual diameter of a hundred miles or more. It "may" have, observe, not it "has," for in fact we know nothing about it, but that it is at any rate less than some few hundred miles in diameter, and it may, for anything we can positively say, not be more than a very large stone, in which case our atmosphere would probably act as an efficient buffer if it struck us; or it may have a mass which, coupled with its terrible speed, would cause the shock of its contact not so much to pulverize the region it struck, as dissipate it and everything on it instantly into vapor.

Of the remarkable investigations of the spectroscope on comets, we have only room left to say that they inform us that the most prominent cometary element seems to be carbon,— carbon, which Newton two hundred years before the spectroscope, and before the term "carbonic-acid gas" was coined by some guess or divination, had described in other words, as possibly brought to us by comets to keep up the carbonic-acid-gas supply in our air,— carbon, which we find in our own bodies, and which, according to this view, the comets are original sources of.

That *we* may be partly made of old and used-up comets! — surely it might seem that a madder fancy never came from the brain of a lunatic at the full of the moon!

COMET OF DONATI, OCTOBER 9TH, 1858.

Science may easily be pardoned for not giving instant reception to such an idea, but let us also remember, first, that it is a consequence of that of Sir Isaac Newton, and that in the case of such a man as he we should not be hasty to think we understand his ignorance, when we may be "ignorant of his understanding," and, second, that it has been rendered at least debatable by Dr. Hunt's recent researches whether it is possible to account for



COMET OF DONATI, OCTOBER 5TH, 1858. (TELESCOPIC VIEW.)

the perennial supply of carbon from the earth's atmosphere, without looking to some means of renewal external to the planet.

The old dread of comets is passing away, and all that science has to tell us of them indicates that, though still fruitful sources of curiosity and indeed wonder, they need no longer be objects of terror. Though there be, as Kepler said, more comets in the sky than fish in the ocean, the encounter of the earth with a comet's tail would be like the encounter with a shadow, and the chance of a collision with the nucleus is remote indeed. We may sleep undisturbed though a new comet

is announced every month, though it is true that here as elsewhere lie remote possibilities of evil.

The consideration of the unfamiliar powers certainly latent in nature, such as belong to a little tremor of the planet's surface or such as was shown in that scene I have described, when the comparatively insignificant effect of the few tons of dynamite was to make solid buildings unrealities, which vanished away as quickly as magic-lantern pictures from a screen, may help us to understand that the words of the great poet are but the possible expression of a physical fact, and that "the cloud-capped towers, the gorgeous palaces, the solemn temples,"—and we with them,— may indeed conceivably some day vanish as the airy nothings at the touch of Prospero's wand, and without the warning to us of a single instant that the security of our ordinary lives is about to be broken. We concede this, however, in the present case only as an abstract possibility; for the advance of astronomical knowledge is much more likely to show that the kernel of the comet is but of the bigness of some large meteorite, against which our air is an efficient shield, and the chance of evil is in any case most remote — in any case only such as may come in any hour of our lives from any quarter, not alone from the earthquake or the comet, but from "The pestilence that walketh in darkness"; from the infinitely little below and within us, as well as from the infinite powers of the universe without.

S. P. Langley.

CARANCRO.

BY GEORGE W. CABLE,

Author of "Old Creole Days," "The Grandissimes," "Dr. Sevier," etc.

IN TWO PARTS: PART I.

I. — SOSTHÈNE.

BAYOU TECHE is the dividing line. On its right is the land of bayous, lakes, and swamps; on its left the beautiful short-turfed prairies of western Louisiana. The Vermillion river divides the vast prairie into the countries of Attakapas on the east and Opelousas on the west. On its west bank, at its head of navigation, lies the sorry little town of Vermillionville, near about which on the north and east the prairie rises and falls with a gentle swell, from whose crests one may, as from the top of a wave, somewhat overlook the surrounding regions.

Stand on whichever one you may, the prospect stretches away, fair and distant, in broad level or gently undulating expanses of crisp, compact turf, dotted at remote intervals by farms, each with its low-roofed house nestled in a planted grove of oaks, or, oftener, Pride of China trees. Far and near herds of horses and cattle roam at will over the plain. If for a moment, as you pass from one point of view to another, the eye be shut in, it is only where in some lane you are walled in by fields of dense, tall sugar-cane or cotton, or by huge, green Chickasaw hedges, studded with their white-petaled, golden-centered roses. Eastward the plain breaks into slight ridges which, by comparison with the general level, are called hills; while toward the north it spreads away in quieter swells, with more frequent fields and larger houses.

North, south, east, and west, far beyond the circle of these horizons, not this parish of Lafayette only, but St. Landry, St. Martin, Iberia, St. Mary's, Vermillion,—all are the land of the Acadians. This quarter off here to northward was named by the Nova Scotian exiles, in memory of the land from which they were driven, the Beau Bassin. These small homestead groves that dot the plain far and wide are the homes of their children. Here is this one on a smooth, green billow of the land just without the town. It is not like the rest—a large brick house, its Greek porch half hid in a grove of oaks. On that dreadful day, more than a century ago, when the British in far-off Acadie shut into the chapel the villagers of Grand Pré, a certain widow fled with her children to the woods, and there subsisted for ten days on roots and berries, until finally, the standing crops as well as the houses being destroyed, she was compelled to accept exile, and in time found her way, with others, to these prairies. Her son founded Vermillionville. Her grandson rose to power — sat in the Senate of the United States. From early manhood to hale gray age the people of his State were pleased to hold him, now in one capacity, now in another, in their honored service; they made him Senator, Governor, President of Convention, what you will. I have seen the portrait for which he sat in early manhood to a noted English court painter: dark, waving