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17/6

THE

ARCHITECTURE

OF THE

HEAVENS.

HOW MANIFOLD, O GOD, ARE THY WORKS! IN WISDOM THOU HAST MADE THEM ALL.

VIEWS

OF THE

ARCHITECTURE

OF THE

HEAVENS.

IN A SERIES OF LETTERS TO A LADY.

BY

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TO

MISS ROSS OF ROSSIE,

THESE LETTERS

ARE

RESPECTFULLY INSCRIBED.

NOTE.

I HOPE none of my readers will expect in this volume a general treatise upon Astronomy: I have not written systematically even upon that portion of the science whose results I intend to expose. It has been my sole aim to state what recent times have evolved concerning the vastness of the Universe, in language so plain, that whoever wills, may henceforth look at the Heavens not without something of the emotion which their greatness communicates to the accomplished Astronomer: and if, in performing this task, I sometimes abandon the style of strict discussion, substitute illustration for proof, or give speculation free wing, perhaps the scientific reader who discovers the offence, will, if he approves of my plan, account it venial.—The Plates are chiefly taken from graphic representations by the two Herschels:—in most cases they will amply compensate for the want of powerful telescopes.

To the foregoing Note, prefixed to the First Edition of this work, I have now to add my thanks for the favour with which my volume has been received by the public:—Encouraged by the rapid sale of a very large impression, I may perhaps venture to hope that it has succeeded in familiarizing many of my countrymen with the sublime truths unfolded by the higher Astronomy.

In this Second Edition, the reader will find a few of the more abstract parts considerably simplified. It is also enriched by an account of those admirable researches concerning the Double Stars which have lately reached this country, from the Imperial Observatory of Dorpat.

I may be allowed to state, that the volume again laid before the public, is intended to constitute the second of a series of six independent but related works, in which I hope to explain and illustrate all those grand relations in the mechanism of Nature which science has yet succeeded in disclosing. The first volume, referring to the Solar System, and to some extent introductory to this one, will be published in a few weeks. A full account of my scheme will be given in the preface to the third volume, which I expect to appear about Midsummer.

College, Glasgow,
20th March 1838.

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PART I.

THE GENERAL OUTLINES OF THE EXISTING UNIVERSE.

LETTER I.

CONSIDERATIONS ON THE SYSTEM OF THE UNIVERSE—SHAPE OF THAT GREAT CLUSTER OR FIRMAMENT WITHIN WHICH OUR SUN IS IMBEDDED.

MADAM,

I HAVE been induced to make the brief series of letters addressed to you, thus public, because of a regret which, I believe, is widely felt, that the discoveries of recent years, which have thrown most unexpected light upon the constitution—present and remote—of the Stellar Universe, should longer continue comparatively unknown, or concealed amid the varied and massive collections of our Learned Societies. Unfortunately, I am not at present in a condition to bestow on these discoveries a shadow of original interest; so that, in description, my pen can have only a

A 2

borrowed liveliness. But as the illustrious men who share the glory of having achieved such acquisitions for mankind, have, not unequivocally, declined the humbler task of reducing them into a popular system, we have only the choice of consenting, that matter of unusual importance shall remain unfitted to fulfil the best purpose of truth—which is to instruct and elevate the general mind,—or to permit the work to be attempted by some one with pretensions no higher than my own.

Previous to the commencement of this century the facts and speculations about to engage us were unknown in science. Before then, the planetary orbits seemed to encircle all accessible space: they had effectively constituted bounds to systematic inquiry; for astronomers had never adventured into greater remotenesses, having, like the people, gazed at the farther heavens with vague and incurious eye—content to admire their beauty and confess their mystery. This period, however, was distinguished by the occurrence of two events, which could not exist in combination, without ensuring important results. The TELESCOPE, formerly of limited range, suddenly assumed a capability of sounding the uttermost profundities; and the man in whose hands it took on this new efficiency, was possessed of a genius to which all opportunities could be entrusted, for it was adequate to the highest. The rise of SIR WILLIAM HERSCHEL marks the first, and still the greatest epoch of the modern astronomy. He was struck for a discoverer in the finest mould:—mingling boldness with a just modesty, a thirsting after large and general views, with a peculiar sensitiveness in regard of *existing* analogies, and a habit of most scrupulous and dutiful obedience to their intimations—he was precisely the man first to quit paths, which through familiarity were common and safe, and to guide us into regions, dim and remote, where the mind must be a lamp to itself, and walk entirely by lights which stream from its internal fountains.

There is one infallible mark of the rise of an original mind. When you see a man in the midst of his contemporaries, not contesting opinions—not quarrelling—but quietly, and without either ostentation or fear, proceeding to resolve by reason, subjects which had hitherto been in possession of "common belief,"—be certain that a signal access of knowledge is awaiting us, for the freshest stamp of divinity is upon that man. Herschel's first remarkable paper gave a promise of this description, and abundantly was it soon fulfilled. It seems to have early occurred to him that the notions—still prevalent—concerning the relation of our firmament,* or whole heavens, to the universe, or rather to infinite space, rest on no better foundation than many long discarded conceptions which found easy acceptance in less advanced epochs of astronomy. The usual inference from the aspects of the sky is, I believe, that *our* skies are infinite, or that stars, as we see them, stretch through all space; which, critically examined, appears only a repetition of the old fallacy, that what is great to us, must be great absolutely, and to all beings,—that a system must be infinite—occupying and constituting creation, merely because *we* cannot descry its boundaries, or reckon up its magnitude by the dimensions of our narrow abode. The firmament, with its countless and glorious

* Once for all, and to prevent ambiguity, let me state, that in speaking of *our firmament*, I mean, not the solar system, but that entire mass of stars, of which, what we see in a clear night is the nearest portion. It will be seen in the sequel, that the proper name for this mass, is *our cluster*.

orbs, is doubtless vast,—perhaps inconceivably so; but, calmly placing the utmost sphere within our possible sight, beside the idea of what is really infinite,—or comparing the vision of man with the reach of an Almighty eye—it flashes instantly upon us that we neither have nor can have positive ground for the assertion that our stars are diffused through all existence. Herschel proceeded to refute systematically this common delusion, and to unfold the true scheme of the universe.

The subject is very unusual, and exceedingly apt to bewilder and overwhelm; so that we shall most safely enter it by aid of illustration: and one occurs to me which exhibits with some precision the progress of our Discoverer's thoughts. —Call up to your mind an Indian of that old America, when civilisation had not yet disturbed the sombre twilight of its forests; suppose him of a tribe whose wanderings had been confined far within the interior of a range of primeval pines,—how natural for his untutored thought to conceive the wood of his nativity infinite, or that space is all occupied with trees! His eye had never lighted upon one external object,—the forms of his infancy were the forms to which his manhood had been alone accustomed; trees had always environed him, and hemmed in his prospect; so that, on being informed by an instructed traveller, of the existence of free and wide savannahs, he must have seemed to hear of something unintelligible and against nature, and have gazed with that very incredulity which fills our minds at the idea of the great Firmament being limited like a Forest—of *our* Infinite being comprehended within Form. But lo!—in his stray wanderings—at a time when his gods smiled upon him—the Indian arrives at a mountain, which rears its summit above the gigantic pines. He attempts it, overcomes its precipices, and descries—a new world! The forest of his dwelling is mighty, and stretches far; but America is mightier, and numbers of forests equal to his, luxuriate upon its plains. Seldom, indeed, is this mountain found. Men wander through centuries, in ancient ignorance, without reaching or scaling an elevation capable of shewing them beyond it; but in a propitious hour, and after long preparation, genius and industry descry it, and straightway the scales fall from our sight. It was the TELESCOPE which in this case pierced the

Pl. I.

Forrester & Nichol lithog.

skies, and revealed the contents of outer regions hitherto unseen by man. And most splendid was the perspective! Divided from our firmament and each other by measureless intervals, numerous FIRMAMENTS, glorious as ours, float through immensity, doubtless forming one stupendous system, bound together by fine relationships. These remarkable masses are located so deep in space, that to inferior telescopes they seem like faint streaks or spots of milky light upon the blue of the sky; but the instruments which had just been summoned into being resolve their mystery, and disclose their myriads of stars. One of these objects, perhaps the most brilliant in the heavens, is represented in Plate I.: it is in the constellation Hercules.* After all, how easy the belief to *its* indwellers, that a mass thus surpassingly gorgeous is—infinite. What wonder although the inhabitant of a planet revolving around one of its central suns, should have mistaken his own magnificent heavens for the universe, and needed the distant and dim vision of

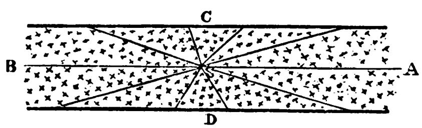
* The Plate referred to is certainly the most inadequate in the volume. It is indeed impossible to give a fitting representation of this magnificent cluster. Perhaps no one ever saw it for the first time through a large telescope, without uttering a shout of wonder.

our firmament, appearing to his telescopes as a starry speck, to remove the veil from his mind, and give him juster notions of the majesty of creation!

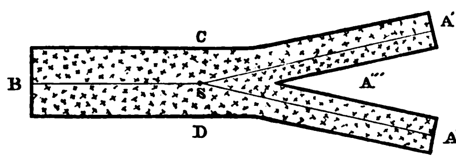
There are truths which, although startling at first, are found so much in harmony with the scheme of Nature, that we are soon chiefly astonished that they never occurred to us before: and I can conceive circumstances in which the Indian, after the foregoing revelation had been made to him, would not fail to descry among the *internal* aspects of his forest, not only distinct intimations of its limitude, but also of its *peculiar shape*, and even *approximate dimensions*. Think of the appearances, which would be mainly remarked by an observant man, as characteristic of his position, were the forest infinite or very extensive. In his immediate vicinity the surrounding trees would be well defined, and of the largest proportions; behind these he would see another range, smaller, but also well defined, and so on through many gradations of size and distinctness, until individual trees could no longer be distinguished, and the view would terminate in an unnamed and vague appearance, which I may be permitted to call a diffused *woodiness.* But if this peculiar background were not seen in every direction, the light of the sky appearing through the trees in different places, the conclusion would be just and manifest,—*that the forest had not the characteristics of one stretching out indefinitely or even equally on all sides,*—that in some directions its edges were nearer than in others, or that it was merely a *group or stripe of trees, having boundaries, and of a particular and ascertainable shape.* With these fresh lights turn again to the heavens, asking what is the case with them? If we were in the interior of an infinite and regular stratum, appearances would necessarily be nearly similar all around us—the aspect of the sky on one side would be almost its picture on every other side. The same, or nearly the same number of visible bodies would, as in the infinite forest, be found every where; and there would come from behind in all directions, through those recesses in which no single star could be descried, something of the same amount of whitish or milky illumination, arising from the combined effulgence of luminaries individually unseen. *But this does not accord with actual phenomena,* which rather agree with the second form of our illustration. It is only when we look towards the MILKY WAY, that these bodies seem to retire indefinitely, and finally to be lost in a diffused *starriness;* and in all other places the intervals between the luminaries are nearly quite dark, *as if there we were closer on the edges of our bed of stars, and therefore saw through it into the external and obscure vacancies of space.* The opinion is thus forced on us anew, that what we term our Firmament is merely a *group* or *cluster* of stars, and, moreover, that it is a group of peculiar configuration, *narrow*, *but greatly elongated in the line of the Milky Way.* Is it not strange that an inference so natural, so palpable, flowing so easily from the phenomena of our brilliant zone, was never drawn before; and that, notwithstanding of that zone shining there, and speaking since "creation's dawn" most invitingly to reason, it should have been left for Herschel, even to so late a day, to rescue it from mythology and mystery, and teach us to look at its countless orbs with emotions loftier than an exciting but useless wonder!

Starting with the foregoing general ideas, let us attempt to ascertain, with definiteness, the shape and dimensions of that great cluster in which we are. In the remaining part of this letter I mean to guide you to the conclusion I have in view, through a series of approximations.

1. Our group, I have said, is certainly an elongated one. A simple diagram will explain how existing appearances are *generally* accounted for by this hypothesis; and the same illustration will indicate the first rude modification necessary to bring it into a more perfect and *minute* consistency with appearances. If a spectator were in a world S in the midst of a stratum or bed of stars, bounded as beneath by the lines C and D, *i. e.* narrow, or, at least, measurable in breadth, or in the directions, SC, SD, but indefinitely

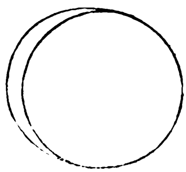


prolonged towards A and B, he would manifestly be engirt by heavens having the general aspect of ours; for, on looking along any line from S towards C or D, he might see through the cluster, and the regions in that quarter would therefore all appear a comparatively dark ground, bespangled with multitudes of distinguishable luminaries; while in the directions SA and SB—before and behind him—his eyes would fail, as ours do when turned to the milky way, in separating the individual bodies, or in recognising the existence of the remoter masses, otherwise than in the silvery twilight coming from their aggregation. Were our milky zone one regular belt, we would, it is thus evident, require no modification of the previous hypothesis; for the supposition that the firmament is a regular oblong stratum, would in that case clearly explain and account for its whole more prominent phenomena; but the Milky Way *is not a regular belt.* An attentive inspection of it, on any favourable night, will shew you, that through one-third of its entire course it *divides into two branches,* which, after flowing considerably apart—leaving between them a comparatively dark space—reunite, and again form a single stream; so that you require a hypothetical figure, which will explain why, in looking before you to any part of that region where the stream is divided, your prospect terminates, not in *one* milky spot, but in *two,* separated by a considerable breadth of space which has no greater number of stars, and not much more general illumination, than the *sides* of the cluster. Now, this peculiarity will be accounted for, if we suppose that our cluster is an oblong *divided at one of its extremities;* for if the sun, S, were in such a cluster as below, a spec-



tator in it would manifestly see one bright spot towards B; *two* equally bright spots, A′ and A″, in the opposite direction; and towards C and D, as before, the background of the heavens would appear comparatively dark; while he would observe a *third*, but limited dark space, of precisely the same character, towards the vacuity A‴, which separates the divergent branches.

The foregoing figure may thus be taken as a first, but most general approximation to a section of our vast firmament; and even as such, I should think it cannot be viewed with an ordinary interest. Perhaps, however, you may find difficulty in apprehending what our firmament really is, or in inferring its entire shape from its chart in *section;* I shall, therefore, without de-parting from the very general and rude mode of illustration I have adopted, endeavour to construct for you its complete or solid form. You know a common grindstone? Suppose, first, that the rim is split in the middle, along the line of the rim, and through about one-third of its circumference; which split, however, does not reach so far down as the centre of the grindstone: also let the divided parts be somewhat separated towards the middle of the division, so that they run along as below, and re-enter after a temporary separa-

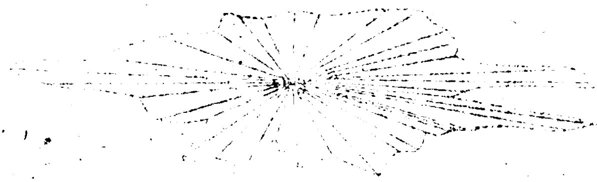


tion. Suppose, secondly, that the sandstone is considerably more porous than stone is,—then let its minute atoms represent stars, the pores or intervals, being the interstellar spaces; and observe what an inhabitant of a sun or world near the centre of a cluster of such configuration would perceive in his heavens. They would be precisely similar to our own celestial vault. Towards their sides the view would be comparatively unadorned—dark space looming from beyond the visible stars; while, in the direction of the circumference, a countless mass of small remote stars would, although separately unseen, illume the sky, forming a splendid zone, divided like our Milky Way through part of its shadowy course. Is it repulsive to compare our magnificent universe to an object so ordinary, so trifling? Alas! endow it once with *Form*, and, whatever its actual dimensions, beside the vastness of the Infinity which environs it, all are shrivelled up, and their majesty disappears! We can speak of our cluster only as of a limited object, a speck, one single individual of an unnumbered throng; we think of it, in comparison with creation, only as we were wont to think of one of its own stars.

2. Hitherto we have used merely the eye—now we take up the telescope. Herschel employed this wonderful instrument to shew him the very minute irregularities of our firmament, upon a principle easily understood. Suppose you were somewhere in a crowd—say, in a church filled with people—would you not, on turning and looking around you in different directions, *see a number of persons somehow proportionate to your distance from the extremities of the crowd, or the walls of the church?* If you saw a much greater number, for

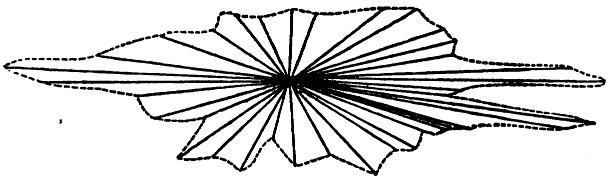
instance, when looking one way, than when looking another way, the inference would surely be natural, that, in the former direction, the mass or multitude of people extended farther than in the latter; and it will be quite conceivable that an arithmetical rule might be found, by which you could *compute* your relative distances in the two cases, from the ends or limits of the assembly. The rule does exist, and is not complex; nevertheless, I am satisfied here if you recognise its *possibility*. Take then a large telescope—one which can go deeply through space—turn it in all directions, count the number of stars in its field in each position, calculate upon this basis your corresponding distance from the extremities of the cluster, and you have the means to a certain extent of accurately charting the firmament. Herschel was fired by this idea. He termed the process a gaging or sounding the heavens—casting out lines, as we do at sea, to fathom and record its profundities. With his peculiar ardour and perseverance, he accomplished at least 700 known observations with a view to determine the elements of a suitable and *accurate* sketch:—Then supposing S the position of our sun, and drawing, in the due directions lines, determined in

Pl. II.



trémities of these [illegible] the [illegible] re-
quired. The above [illegible] is [illegible] imaginary,
being simply intended to exhibit the rationale of
Herschel's *method* [illegible] the [illegible] actually obtained [illegible]

length by the arithmetical rule spoken of, as corresponding to depths indicated by the quantity of stars in each *gage*, the mere joining of the ex-



tremities of these lines gave him the section required. The above wood-cut is purely imaginary, being simply intended to exhibit the rationale of Herschel's *method;* the result actually obtained by him is shewn in Plate II. It has the aspect, and is larger than the size under which that firmament—so magnificent to us—may appear to spectators in remote clusters situated in a line, passing through the Milky Way, and nearly over our heads;—spectators who, perhaps, are even now marvelling, as they descry it through their telescopes, what that sprawling spot may be, which just somewhat, and only in one trifling point, bedims the azure of their heavens! *

* I proposed to investigate, not only the shape, but also the *dimensions* of our cluster. In respect of the latter, we cannot, of course, hope for more than the remotest approximation. It was Herschel's idea, that, towards the sides or shallow parts, there might be a line of forty successive stars, at equal distan-

3. There is obviously one source of error in Herschel's sketch, which we may be able to eliminate, and thus approach still nearer the truth. Throughout the whole speculation you find the latent assumption, *that the stars are distributed equably*—not meaning that there are no small clusters within the firmament, such as the Pleiades, or the brilliant Prœsepe in Cancer, but that even such clusters are scattered, *generally*, in all directions, on a principle approaching to indifference. Our astronomer himself searched somewhat into this matter, and he saw enough to convince him that his section has only the value of an approximate representation. Towards the

ces from each other, between our sun and its extremities, while in the direction of the Milky Way there are in some places upwards of 900! The Milky Way, however, is by no means equally profound. It is, as we will soon see, an extremely irregular zone. I may remark here, that the numerical statements in this note and throughout the text, are dependent on Herschel's notion of the relative light or magnitude of the stars—a subject on which astronomers are by no means agreed, and which demands further and much more critical scrutiny. For the sake of the simplicity of my volume, which is essentially a *sketch*, I did not think fit to open the original question in the first instance; and I still retain the estimate of this great inquirer, because the leading truths I am unfolding are independent of their absolute accuracy. The subject, however, is exceedingly interesting, and I hope to discuss it fully on another opportunity. A new field of speculation in this matter has recently been opened by Steinheil.

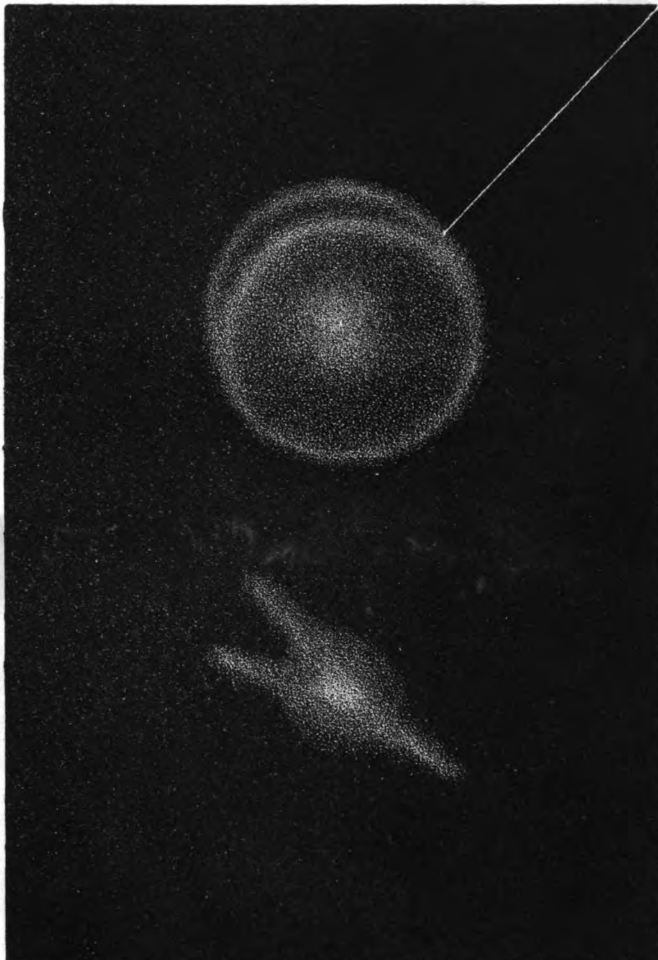
Milky Way, and especially within that zone, the stars are much more compressed, or closer, than elsewhere: and I find among Herschel's journals, notices of various kinds, indicating *breaks* in the regular progression of stars—absolute vacuities—chiefly appearing to *detach* the Milky Way from the interior mass, and to present it more as a RING OF STARS, really separated from the rest of the stratum, but environing it. Sir John Herschel decidedly inclines to this opinion; and he thinks, moreover, that we are not placed in the centre of the included stratum, but in an eccentric position, *i. e.* nearer one-half of the ring than its opposite half—thus accounting for the vastly superior brilliancy of this magnificent girdle in southern latitudes.* The telescope will

* The following are Sir John s words:—"The general aspect of the southern circumpolar region, including in that expression 60° or 70° of S. P. D., is in a high degree rich and magnificent, owing to the superior brilliancy and larger development of the Milky Way: which, from the constellation of Orion to that of Antinous, is in a blaze of light, strangely interrupted, however, with vacant and almost starless patches, especially in Scorpio, near α Centauri and the cross; while to the North it fades away pale and dim, and is in comparison hardly traceable. I think it is impossible to view this splendid zone, with the astonishingly rich and evenly-distributed fringe of stars of the third and fourth magnitudes, which form a broad skirt to its southern border, like a vast curtain—without an impression, amounting to a conviction, that the Milky Way is

ultimately resolve all these problems; for, as I will explain in next letter, it not only brings new objects within sight, but also informs us, at the same moment, in what particular zone or sphere they are located: the labour, however, of thus dissecting our massive firmament is scarcely more than begun.—I have now to state to you a remarkable circumstance, perhaps the strangest and most unexpected which modern astronomy has revealed. Although the telescope has not yet enabled us to lay out the plan of our cluster, from *interior* surveys, it exhibits what seems its very *picture*, hung up in external space! Look at Plate III. It represents an object resting near the outermost range of telescopic observation, not resolved, but doubtless a great scheme of stars, which is the *fac-simile* of that to which we belong! It has its surrounding ring of the precise form we have been inclined to attribute to our zone; and its section, figured in the same plate, or the aspect it would take on to a spectator at a vast distance, looking from

not a mere stratum, but an annulus; or, at least, that our system is placed within one of the poorer and almost vacant parts of its general mass, and that eccentrically, so as to be much nearer to the parts about the cross, than to that diametrically opposed to it."

Pl. III.



the direction of the white line in the margin, has the closest general resemblance to Herschel's sketch.* Singular affinity of forms! What link, what far-reaching sympathy can connect these twin masses—that unfathomed firmament and ours? What virtue is there in a shape so fantastic that it should thus be repeated? Or what is the august law, thus working at the opposite extremities of space, which has caused those corresponding shapes to come into being? Prompted by reverential curiosity, we eagerly put such questions; but to resolve them baffles our loftiest philosophies!

Thus then have we entered on new views; we are introduced to perhaps the grandest phenomena in the Stellar Universe. We have been raised to an elevation never scaled before, below which Creation and its wonderful arrangements are expanded; and be it never forgotten, we owe this conquest to the genius of one Man.

* It adds considerably to the interest attached to this cluster, that a spectator in it must see ours, precisely as we see it, *i. e. sideways;* so that our firmament will have, to the inhabitants of its stars, quite the aspect which it presents to us. The two figures in Plate III. will explain any ambiguity in pages 15 and 16, where reference is made to the *section* and *solid form* of our cluster. Perhaps these should now be reperused.

But as the circle of knowledge has extended, the sphere of our recognised ignorance—that dark sphere which hems in what we know—has increased likewise. How different is Astronomy now, taking cognizance of the number of these firmaments, attempting to determine their magnitude, and account for their form, from the Astronomy of a recent day, which was limited to discussions concerning the habits of the small bodies attending our sun, and which, because of its memorable success, boasted that as a science it was complete? There was true prophecy in the exclamation of La Place, who, although then knowing more than any man of the mechanism of the Heavens, said earnestly on his deathbed, "That which we know is little, that which we know not is immense." And the spirit was partaken of by Newton in the very flush of his immortal discovery, when, with the modesty of all great minds, beside whose infinite aspirations the highest possible attainment is ever insignificant, he is recorded to have spoken thus:—"I am but as a child standing upon the shore of the vast undiscovered ocean, and playing with a little pebble which the waters have washed to my feet."

LETTER II.

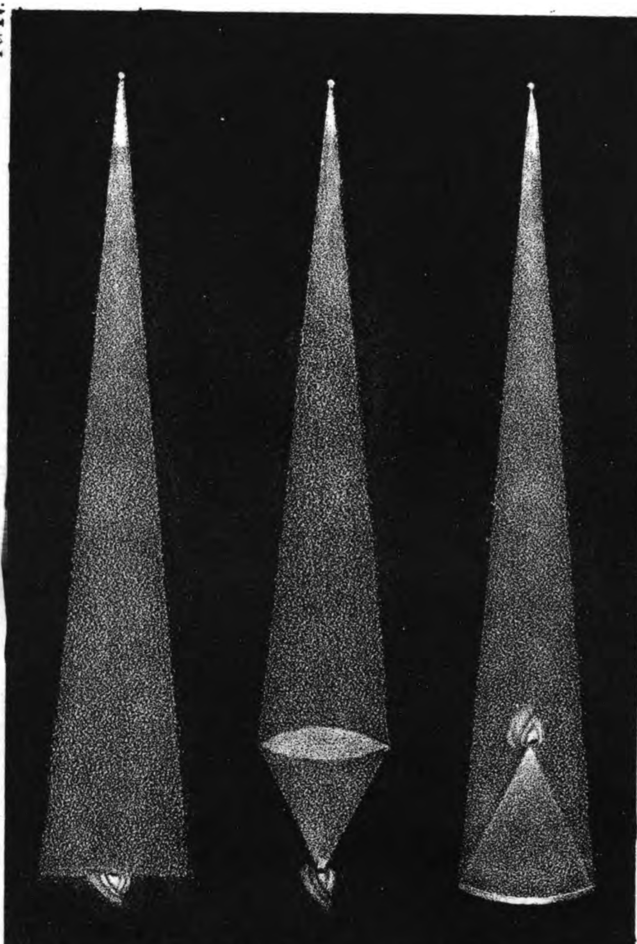
ON THE POWER AND REACH OF TELESCOPES.

It is expedient to digress a little in this place. We have spoken much of the power of telescopes, and of the profundities through which they pierce; and it will be pleasing to you to become satisfied as to the possibility of such power—to be persuaded that I am not amusing you with romance. A brief and simple explanation of the principle on which telescopic power depends, will accomplish this object; and you will then yield me your belief, instead of your mere confidence, when I refer again to what, but a short time ago, would have seemed an incredible fable.

Although not according to the strict mode of expression, it suffices here to say, that we see objects, or that they occasion in a spectator the sensation of seeing, when a certain luminous influence radiating from them, enters the eye in such quantity, as can irritate or excite the nerve of vision. Bright or visible bodies send out this influence in straight lines, and on all sides of them, so that the luminous matter will always be *thinner* the farther it is from the radiating point, as it cannot be dispersed without suffering diffusion—a truth which is pictorially illustrated in Fig. 1, Plate IV., where a luminous point is represented raying out beams. It follows, accordingly, that as the eye is nearer or farther from the source of the rays, the greater or less will be the amount of light received by it; and there will always be a point of distance, intended to be exhibited in the figure, where no more than is barely adequate to cause the sensation of sight, falls upon the retina. This would manifestly be the *remotest limit of visibility* in that case and to that eye. Let the spectator retire, although only by the smallest quantity, and the luminous point would disappear and be lost in space.

Such being the process of vision, may we hope ever to extend the boundaries of our sphere, to reach depths, from which the physical constitution of humanity might appear to have excluded us? There are plainly but two imaginable methods by which so great an aim may be accom-

Pl. IV.



plished,—either we must act upon the shining body so as to compel it to give forth light of higher intensity, or we must, if I may say so, *enlarge the pupil of the eye*, and enable it to receive a greater number of rays. The former method is wholly impracticable—no demonstration is needed to prove it so, for bodies lying profoundly in space are manifestly remote from our control; but if by any marvellous artifice we *can produce a virtual enlargement of the pupil of the eye*, our success will be equally brilliant and sure. Nature, indeed, has expressly pointed out this very plan, for she acts upon it herself. Birds and other creatures which wander in the night have all large pupils, and our own organ of vision enjoys a limited power of expanding in the dusk, so that, when the light is faint, we take in a larger than usual ray, and discern objects, which must have been unseen, unless for that preparatory change.

Turn, without farther preliminary, again to Plate IV. You know a *lens*—a common burning-glass? Hold such a glass before the beams of the sun, and it is seen to compress much of the light which falls upon its surface into a bright pencil behind it. Suppose, now, a large lens of this description placed, as in Fig. 2, immediately in front of an eye, looking towards a radiating point which is nearly invisible through faintness, and notice the change of circumstances.* Instead of the eye receiving, as in Fig. 1, only a faint and almost imperceptible quantity of light, it appears taking in *the whole mass of rays, which pass through the large lens in front of it*, for the lens has united that quantity, and caused it to converge into a pencil sufficiently minute to enter the eye. A portion of the rays which reach the lens from the luminous body, do not indeed pass through it, and are therefore lost to the eye; but as the deduction is not great, *the eye in the position referred to would receive nearly as much light as if its pupil had been enlarged to the dimensions of the lens, and its power would necessarily be increased in proportion.* Thus armed, through what a remoteness might we reach that luminary, formerly just escaping us! Without the slightest hazard of its fading away, it might evidently be withdrawn into space, until the whole light compressed by the lens were not

* It will be recollected that I am not describing the construction of a telescope, which is beyond my province and present intentions; I merely indicate the sources of its power.

more intense at the bright point of its pencil, than the faint ray at the pupil in Fig. 1; and this mighty acquisition has been gained by the simple interposition of a lens! We have been so long accustomed to the telescope, that Wonder has yielded before Familiarity; but perhaps we may yet imagine what amazement spread over Europe when the rumour was first heard, that by a process of such simplicity, the hither boundaries of the unseen had been passed, and remote faintly-twinkling worlds, brought near for the inspection of man! No Arabian tale could have seemed wilder, and no fabled charm of more incredible potency. Art in our own day has often seemed to realize the fables of the most wonderful talisman; but our greatest advances—our mightiest triumphs over time and space—are mean and commonplace beside the achievements of the telescope. Let our race labour on! the best magic—one loftier and more potent than Agrippa ever dreamt of, is all within its reach:—The assistant Genius is Nature herself; and the spell, that Intellect which comprehends her.

Lenses, however, or *refractors*, are not the sole instruments by which light can be collected and compressed. A concave mirror of polished metal answers the same purpose; only, as seen in the remaining figure of Plate IV, the mirror throws the convergent pencil forward, while refractors throw it behind them. I need not remark that the vital source of power, in either case, is the size or diameter of the reflecting mirror or refracting lens; for, according to its diameter, the pupil of our new eye is great or small. Refractors of a moderate size are common, but large ones are very rare,—Art still failing in the regular construction of great lenses. I am assured, however, that instruments exist of this description, through which a quarter of a mile in the moon is appreciable, and in which one of the mountains of that enigmatical luminary may be distinctly seen, and its contour sketched, although magnified so as to occupy the whole field of view.* It has hitherto been easier to

* The magnifying power of a telescope is not the same as the space-penetrating power, but it depends upon it. The space-penetrating power rests wholly in the size of the speculum or object-glass—it is that power which will recognise a faint light at a great distance; the magnifying power again is chiefly in the eye-piece, which is a mere microscope, and enlarges the dimensions of the object brought by the other power into view. It is clear, however, that no object which is not presented with great light, can be greatly magnified,—as its light, by being

work in metal than in glass, and accordingly powerful telescopes, on the reflecting principle, are most frequently employed. Reflectors of nine inches diameter have long been in general use; a considerable number of twice this size have likewise searched the heavens with singular effect; but our *gigantic* instrument is that, perfected by Sir William Herschel, after incredible labour, whose mirror reached the vast magnitude of FOUR FEET diameter. Dwell for a short time on the dimensions and consequent power of this wonderful telescope, and I venture to say you will no longer be sceptical when I speak of seeing into space. If the mirror had reflected all the light which fell upon it, it would virtually have been an eye with a pupil of four feet diameter; that is, it would have been more powerful than the human eye, *by as much as the surface of its enormous disc exceeded the small surface of our pupil!* And making allowance for much light being unavoidably lost, still how great must have been its power! That body is faint indeed,

spread or diffused over a large space, would become too thin or faint to be recognised. You may thus infer the penetrating power of the telescope referred to in the text, from the fact that it can permit of so great an amplification of a lunar mountain, and still present it as a visible and distinct object.

or inconceivably remote, of which it could give us no hope of intimation; and it is no marvel that it sounded our firmament, mighty as it is, and ranged unwearied among the abysses of the dark Infinite beyond. The lustre with which it clothed the bodies in our immediate vicinity is said to have been inexpressibly beautiful. Herschel himself, intent on far discovery, seldom looked at the larger stars; and, because their blaze injured his eye, he rather avoided their transit. But he tells us, that at one time, after a considerable sweep with his instrument, "the appearance of Sirius announced itself, at a great distance, like the dawn of the morning, and came on by degrees, increasing in brightness, till this brilliant star at last entered the field of the telescope with all the splendour of the rising sun, and forced me to take my eye from the beautiful sight."

The principles just adverted to, shew how we can readily compute the *precise and definite power of our telescopes*, or the distance to which they reach, compared with the naked eye; and such knowledge is of highest importance, as, without it, we could not estimate the relative profundities of the objects which different telescopes reveal. The first element or essential is manifestly the size of the speculum or object-glass, estimated in comparison with the pupil of the eye; and the second is the proportion of light lost in the process of reflection or refraction. If no light were lost, the artificial eye and the natural eye would, as I have said, be efficient, according to the comparative magnitudes of what I may term their respective *pupils;* but as light always is lost,—and the amount may be determined by careful experiment,—a certain deduction must be made from the telescopic power. It were useless to go into the minutiæ of this computation—I merely desire that you should comprehend its grounds and rationale. A few precise statements, however, will be interesting. Herschel considered that his ten-feet telescope had a space-penetrating power of 28½, *i. e.* it could descry a star 28½ times farther off than the naked eye can; to one of his twenty-feet telescopes he assigned the power of 61, and to another of much better construction, the power of 96. The space-penetrating power of the forty-feet instrument he settled at 192! But as you may not have a sufficient idea of the profundities represented by these numbers, I shall convert them into more definite quantities. The depth to which the naked eye can penetrate into space, appears to extend to stars of the twelfth order of distances,* *i. e.* it can descry a star twelve times farther away than those luminaries, which, from their superior magnitude, we suppose to be nearest us. Multiply, then, each of the foregoing numbers by twelve, and you have, as a first approximation to the *independent* powers of telescopes, a new series of figures, indicating how much farther they can pierce than the first or nearest range of the fixed stars. In the case of the forty-feet reflector, this number is 2304, which signifies, that if 2304 stars, extended in a straight line beyond Sirius, each separated from the one before it by an interval equal to what separates the still immeasurable Sirius from the earth—the forty-feet telescope would see them all.—I subjoin only one farther statement:—the same instrument could descry a cluster of stars, consisting of 5000 individuals, were it

* This is Herschel's computation, which, as I have said already, has been questioned. I repeat, that I shall adhere throughout to his estimates; nor will the error therein involved affect one of the general truths which I mean to expose.

situated three hundred thousand times deeper in space than Sirius probably is; or, to take a more distinct standard of comparison, were it at the remoteness of 11,765,475,948,678,678,679 miles! *

* The limits to the space-penetrating power of telescopes is manifestly this:—No object fainter than the *general light* of the skies—a light constituted by the intermingling of the rays of all the stars—will ever be seen. Herschel calculated, however, that a telescope, at least three times more powerful than his, might still be used. There are mechanical difficulties in the way of grinding complete metallic specula of such dimension, but might they not be ground in parts? In a letter addressed to me by Sir David Brewster, on occasion of our proposing to erect a new and splendidly-furnished Observatory in Glasgow, is the following interesting paragraph:—"To such an Observatory, where the finest achromatic might be accompanied with a better reflecting telescope than has yet been made, it would be a leading object to delineate with precision the hills and valleys of the moon. This planet is much within our reach; and an accurate knowledge of the phenomena it presents, and of the changes these undergo, would be a great and most interesting contribution to science. When we compare the telescope in Newton's time to that of Sir William Herschel's, we need scarcely despair of discovering the structures erected by the inhabitants of that luminary. An achromatic object-glass of the same size as the speculum of Sir William Herschel's forty-feet telescope, would certainly accomplish this; and no person can say that it is impracticable to do in glass what we have done in metal. Had I the means, I would not scruple to undertake the task of building the lens in zones and segments." No man can doubt that knowledge sufficient to immortalize our age would result from an instrument like that referred to by this distinguished philosopher, although the mechanical arts have not yet furnished us with an appa-

It is important to remark, that one telescope may easily be adjusted to different space-penetrating powers. Its highest power is, of course, defined and limited by the diameter of the speculum; but we have only to confine that speculum, *to contract its pupil*, by placing an opaque circular rim of greater or less breadth around the mouth of the tube, to obtain whatever degree of inferior reach we desire. This artifice enables us to take, without trouble, an observant *walk* through space. We know, for instance, that the naked eye can perceive stars of the twelfth order of distances, so that whatever we see without telescopic aid must lie within the sphere at whose outer circumference stars of that order are placed. A telescope with a space-penetrating power of 2, or which reaches to the 24th order of distances, will of course shew us much more than the naked eye; but, whatever additional it reveals, must, in the main, lie between stars of the 12th and stars of the 24th order; so that we have not only new discoveries, but a view of the contents of that particular stratum or *layer* of the firmament,

ratus which would ensure its being easily used. The unwieldiness of Herschel's large telescope was one great cause of its comparative failure as an instrument of discovery.

which surrounds our visible sphere.* By employing a power of 3, the next layer might be ex-

* I doubt not you will start a question here:—Is not this conclusion dependent on the hypothesis, that *stars are all of the same magnitude?* For instance, a number of bodies descried by the space-penetrating power referred to, may be *very small*, and concealed from the naked eye by their *smallness*, not by their *distance*; so that they may lie much nearer us than even the twelfth order of distances. I freely grant that we have good reason to believe that the stars vary in size,—perhaps the limits of magnitude, *i. e.* the size of the largest and the smallest, are very remote from each other:—The connection of double stars of very different magnitudes (see Part II.) demonstrates this; and the same might be deduced from the theory given of the formation of stellar bodies, in Part III. of our work. The speculations over which we have gone, however, depend only on the assumption that we may assume a certain *mean* or *average* magnitude; in other words, that the bodies of different magnitudes are somewhat equally disseminated through the spaces around us: but the investigation referred to in the text immediately above, will not be accurately accomplished until we are in possession of an amount of positive information regarding the actual varieties of the stars. There is reason to suppose, that future investigation may remove such doubts; for so soon as we obtain instruments capable of measuring the actual distances of the stars from the earth—an achievement perhaps not *much* above present attainment—we will be able to tell exactly what are the relative sizes of the bodies, within the sphere, whose extreme boundary has been subjected to measurement; and as these may be taken with little admixture of error as representatives of the dimensions of the bodies beyond that sphere, the heavens may be charted or constructed, on the ground of the information they will convey.—Let me emphatically remind you—of what you must never lose sight—that in the spheres we are tracking, we are not on the ground of absolute certainty, nor can we attempt to fix and define all that is to be found there. If we attain a notion of the gene-

plored ; and advancing thus, as far as our powers will sustain us, we may yet complete the speculations referred to near the close of last letter, and take cognizance of the *whole interior structure of the cluster wherein we are.*—Mean time, however, we will proceed no farther with speculation ; and therefore I close this letter by quoting, in illustration of the above, Herschel's graphic account of his treatment of one of the richest and deepest portions of the Milky Way. He had previously prepared four telescopes in the manner described—with a series of gaging or sounding powers, ascending in regular progression. He adjusted the finder of his seven-feet telescope to the powers of 2, 3, and 4 ; to his night-glass he gave space-penetrating powers of 5, 6, 7, and 8 ; to his seven-feet reflector he gave powers of 9, 10, and upwards, to 17 ; with his ten-feet reflector he continued the series from 17 to 28 ; and, thus amply prepared, he undertook to explore a particular spot. " I selected," says he, " the bright spot in the sword handle of Perseus,

ral forms, or of the *shadows* of mighty truths, our journey will have its success. To carry into such regions the full light of reason, to surmount all difficulties, and clear away all doubts, is reserved for after ages.

as probably a protuberant part of the Milky Way in which it is situated. At the time of observation, not a star in it was visible to the naked eye. In the finder, with a power of 2, I saw many stars, and, admitting the eye to reach to stars at the distance of the twelfth order, we may conclude that the small stars which were visible with this low power, are such as to contribute to the brightness of the spot, and that their situation is probably from between the 12th to the 24th order of distances. . . . . I then changed the power from 2 to 3, and saw more stars than before, and changing it again from 3 to 4, a still greater number became visible. The situations of these additional stars were consequently between the 24th, 36th, and 48th order of distances. With the gaging power 5 of the night-glass, I saw an increased number of stars; with 6, more stars and whitishness became visible; with 7, more stars, with resolvable whitishness, were seen; and with 8, still more. The stars that now gradually made their appearance, therefore, were probably scattered over the space between the 48th and 96th order of distances. In the seven-feet reflector, with the gaging powers 9 and 10, I saw a great number of new stars; with 11 and 12, a still greater number, and more resolvable whitishness; with 13 and 14, the number of visible stars was increased; and was so again with 15; and with 16 and 17, in addition to the visible stars there were many too faint to be distinctly perceived." And so did the philosopher go on—invoking space, and summoning up multitudes of worlds—through all the powers of the ten-feet telescope, when I find the following entry: "With the whole space-penetrating power of the instrument, which is 28, the extremely faint stars in the field of view obtained more light, and many still fainter suspected whitish spots could not be verified for want of a still higher gaging power. The stars which filled this field of view were of every various order of telescope magnitudes; and, as appeared by these observations, were probably scattered over a space extending from the 204th to the 344th order of distances."

LETTER III.

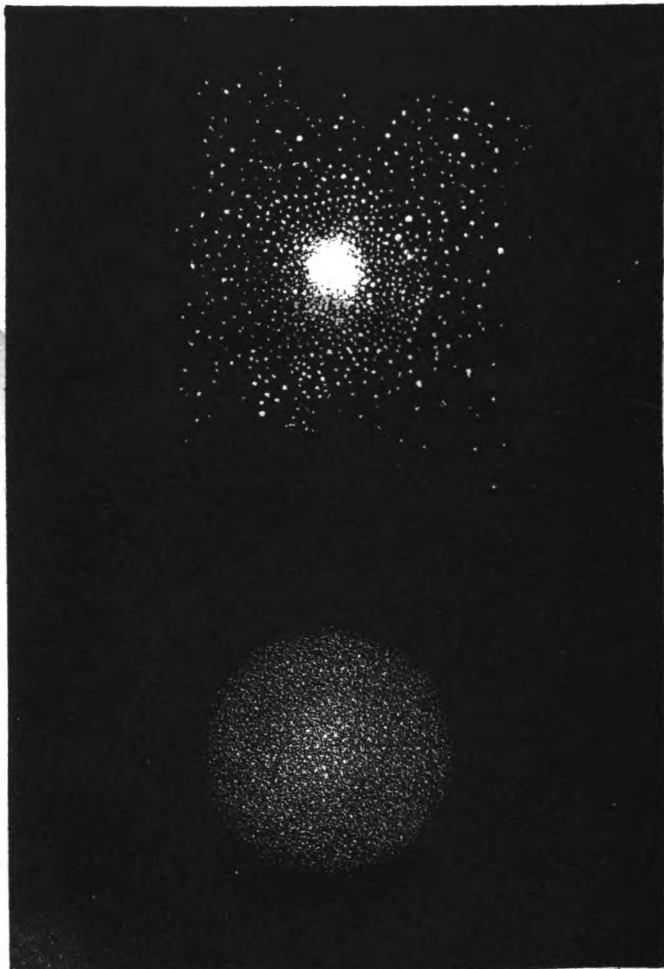
ASPECTS, FORMS, AND DISTANCES OF REMOTE CLUSTERS.

WE resume our progress. The fact has been already established of the existence of vast clusters distinct from ours, sustaining an independent position, as individual constituents of creation. Let us now go forth into infinity among these firmaments, and ascertain their character.

The number of such masses is very great. In the northern hemisphere, after making all allowances, those, whose places are fixed, cannot be fewer than between one and two thousand; and you will have a good idea how plentifully they distributed, by remarking that this is at least equal to the whole number of stars which the naked eye may perceive in any ordinary night. These clusters, the general aspects of which I am now to describe, have very various appearances to the telescope. In many of them, individual stars are distinctly defined. As they become more remote, the distances or intervals between the stars diminish, the light also growing fainter; in their faintest stellar aspect, they may be compared to a handful of fine sparkling sand, or, as it is aptly termed, *star-dust;* and beyond this we see no stars, but only a streak or patch of milky light, like the unresolved portions of our own surrounding zone. This is the state in which they are more properly called Nebulæ, and in which there is risk of confounding them with a singular substance not partaking of the nature of stars, but very common in our firmament. It was in reference to this substance, that I spoke of allowance to be made before estimating the number of known clusters. It has not yet been distinguished or separated in many cases from remote and unresolved clusters; a circumstance much to be regretted, the more especially as principles exist, by which an approximate determination might, without difficulty, be attained.

In my first letter I drew your attention to that splendid object in the constellation Hercules, represented in Plate I. Look at it again, and imagine its magnificence. This cluster, in respect of its leading characteristics, is a good

Pl. V.



Forrester & Nichol lithog.

Pl. VI.

Forrester & Nichol lithog.

specimen object, as it is a representative or type of a very large class. Notwithstanding the partial irregularity of its outline, it seems almost a spherical mass, in which, with a degree of greater compression probably towards the centre, the stars are pretty equably and regularly diffused, so that to the inhabitants of worlds near its central regions, its sky would spangle uniformly all around, and present no phenomenon like the Milky Way in ours. In Plates V. and VI. are representations of a few more of these spherical clusters, some of which, however, shew decided and great compression about the centre; a circumstance which would manifestly much augment the proportionate number of orbs of the first magnitude, in view of those living within the compressed portion, and thus render their visible heavens inconceivably brilliant. The same plates exhibit the degrees of distinctness with which these clusters appear to us. One of the figures in Plate VI., you will observe, is a very faint object, placed near the outermost verge of the sphere within which our mightiest instruments can descry individual stars; it is already in the condition of *star-dust*, almost fading into an irresolvable nebula.

Clusters, however, are by no means confined to the spherical form. Our own, and its curious cognate, are exceptions you already recognise, and there are many other equally remarkable shapes. The left hand figure of the upper line of Plate VI. represents a very singular form (30 Doradûs), sketched by Mr Dunlop at Paramatta; and we are just given to understand that it is still stranger than it here appears. Sir John Herschel, whose return from the Cape of Good Hope, laden with spoils, all Europe is anxiously expecting, has recently written as follows, concerning those Magellanic clouds which have been long regarded as the wonders of the Southern skies. "The Nubecula Major and Minor are very extraordinary objects. The greater" (see Plate VII. where it is represented from Dunlop) "is a congeries of clusters of irregular form, globular clusters and nebulæ of various magnitudes and degrees of condensation, among which is interspersed a large portion of irresolvable nebulæ, which may be, and probably is, *star-dust*, but which the power of the twenty-feet telescope shews only as a general illumination of the field of view, forming a bright ground on which the other objects are scattered. Some of the objects

Pl. VII.

in it are of very singular and incomprehensible forms; the chief one especially (30 Doradûs), *which consists of a number of loops united in a kind of unclear centre or knot, like a bunch of ribbons, disposed in what is called a true-love's knot!* There is no part of the heavens where so many nebulæ and clusters are crowded into so small a space as this "cloud." The Nubecula Junior is a much less striking object. It abounds more in irresolvable nebulous light; but the nebulæ, and clusters in it are fewer and fainter, though immediately joining to it is one of the richest and most magnificent globular clusters in the hemisphere (47 Toucani)." Fancy a firmament shaped like a lover's knot; and, what is more, a group of firmaments manifestly related! The assertion is assuredly warranted, that when this Astronomer is restored to England, we shall obtain a wider extension of our knowledge of the general universe, than has befallen since the time of his great Father's discoveries.

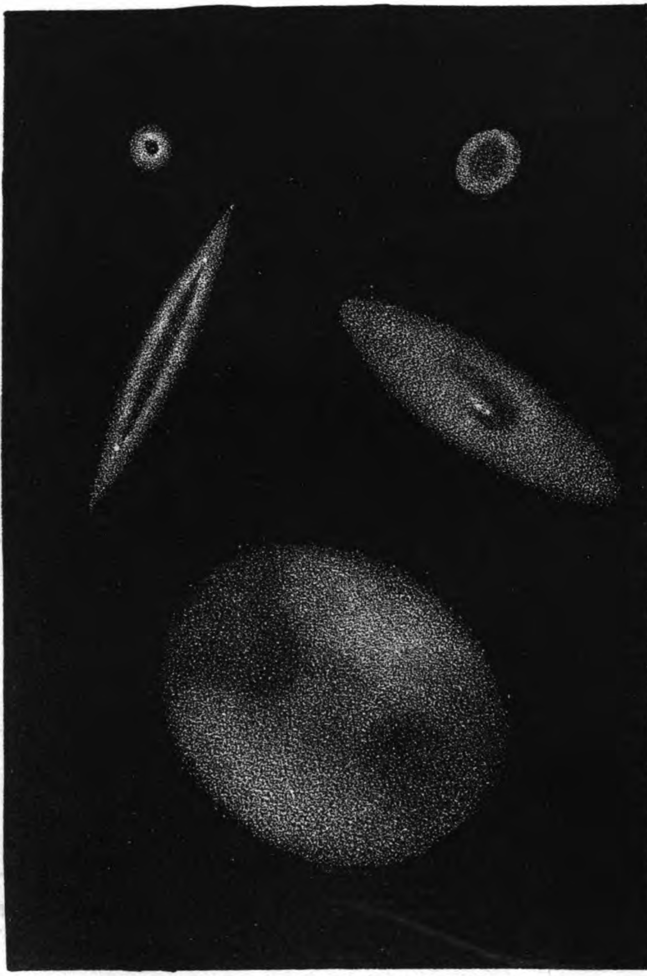
But, perhaps, it is when we arrive among the almost bewildering multitudes of unresolved systems, that we are most forcibly struck by the variations of their fantastic shapes. The unresolved clusters being at depths much profounder than the sites of the others, the sphere appropriated to them is of course of larger radius, and far more capacious; so that there is *room* for great numbers, and also a more wonderful display of variety. Plate VIII. exhibits a few of these curious shapes. The annular form is sometimes met with,—one fine instance is in the constellation LYRA. The oblong sharp hoop represented in the plate, is probably likewise a large ring, appearing sharp only in consequence of its oblique position towards us. How different utterly from ours, must be the aspects of the sky to the inhabitants of such a firmament! The space within the ring is nearly a blank, but not perfectly so, a very thin shade of light spreading over it; so that if any intelligent eye looks from within the space upon what it may well consider its universe, —towards its sides there will be nearly an utter blank, and engirdling it round, a zone of the most dazzling lustre. Perhaps the most peculiar of all, however, is that largest object in the Plate referred to. It has the shape of an hour-glass, or dumb-bell; the two connected hemispheres, as well as the connecting *isthmus*, being bright and beautiful, manifesting a dense collection of stars in those regions; while the oval is completed by

[illegible]

Plate VIII. [illegible] shapes. Th[illegible] [illegible] constellation [illegible] in the [illegible]

[illegible] that if any intelligent eye looks [illegible] the space [illegible] it may well [illegible] —towards its sides there will be nearly as [illegible] them, and engirdling it [illegible] of the [illegible] lustre. Perhaps the most [illegible] of all, however, is that [illegible] object in the Plate referred to. It has the shape of an hour-glass or dumb-bell; the two connected hemispheres, as well as the connecting isthmus, being bright and [illegible] manifesting a dense collection of stars

Pl. VIII.



two spaces, which do not transmit a greater quantity of light, or indicate the presence of a larger number of stars, than the comparatively vacant interior of one of the annuli. We are lost in mute astonishment at these endless diversities of character and contour. They indicate among the Forms of these remote regions a variety as great as that which distinguishes the minute things around us. Not improbably it is one aim of the stupendous System of Evolution of which Creation as it exists is only one phase, to develope all possible variety, to exhibit how, without infraction of stedfast law, Being may be infinitely diversified, and room found for unfolding the whole riches of the Almighty.

It was indeed a bold conception, after having recognised the meaning of these dim lights, and created them into magnificent firmaments—an achievement which would have filled and engrossed most men—to undertake, besides, to compute their relative distances, and to lay down their plan. But, undaunted even by the idea of a chart of the firmamental universe, Herschel undertook to define that portion within reach of his telescopes, and thereby to indicate what it might be beyond them. The principles referred to near the close of last letter, apply at once—although subject to future modification—to the inquiry now opened. The power of a telescope, it will be remembered, can always be compared with the human eye,—as we know the reach of the eye, so we know the reach of the telescope; and if that power be observed which first descries a star, a simple calculation will inform us, in terms of the general distances of the stars, how remote the object is. To ascertain the distance of a cluster then, note the space-penetrating power of the instrument *which first succeeds in revealing its distinct stars*, and twelve times that power will be an approximation to the required distance. Herschel, by using comparatively small telescopes, thus fixed the remoteness of forty-seven resolvable clusters—ten of which were upwards of nine hundred times more distant than Sirius. Plate IX. represents this chart, with the distances affixed.* By larger instruments the determinations might be greatly extended; but, though the

* Of course this is a mere chart *in section* of these clusters. They do not lie in one plane, and therefore cannot be otherwise represented than in section. It is now very imperfect and incomplete: nevertheless it will be interesting. The circles indicate the distances.

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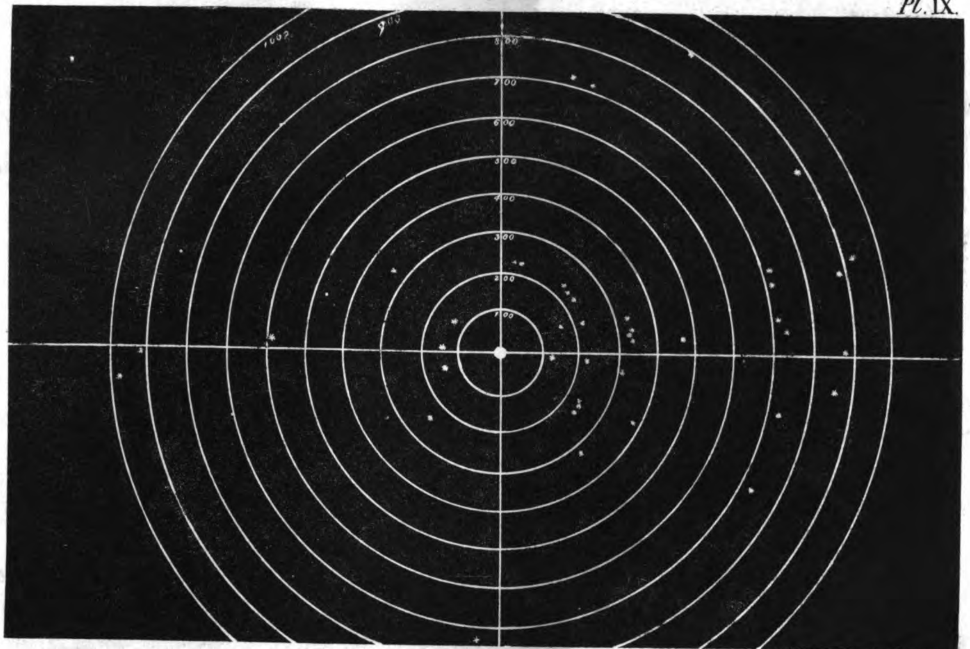
Pl. IX.



Forrester & Nichol lithog.

fields are white, the labourers have been few.— Inasmuch as the element by which the distance is fixed, is the *resolvability* of the cluster, we cannot come, except by guess, at any conception of the profundities of the milky or nebulous firmaments. A vague guess, however, may be hazarded. How far away, for instance, would the clusters, whose depths we know, require to be removed, in order to look as mere streaks, and to baffle the powers of the best telescope ? Suppose that a cluster, ascertained as above to be of the 900th order of distances, were first seen as a whitish speck by a telescope, whose space-penetrating power is 10, it is easy to calculate how far off it must be, to be first descried as a faint spot by an instrument whose power is 200. It would evidently be just 20 times farther removed from us, or at the enormous remoteness of 18,000 times the distance of Sirius. Many unresolved clusters are undoubtedly as profound, and very many still profounder in space. Calculating from the elements of a few known clusters, Herschel reaches the depth of the 35,175th order of distances, in which some of these nebulæ must lie !

And is even *this*—the UNIVERSE ? Where are we, after all, but in the centre of a sphere, whose circumference is 35,000 times as far from us as Sirius—and beyond whose circuit, Infinity, boundless Infinity, stretches unfathomed as ever? We have made a step, indeed, but perhaps only towards acquaintanee with a new order of *infinitesimals.* In our first conceptions, the distance of the earth from the sun is a quantity almost infinite;—compare it with the intervals between the fixed stars, and it becomes no quantity at all, but only an infinitesimal; and now, when the spaces between the stars are contrasted with the gulfs of dark space separating firmaments, they absolutely vanish below us. Can the whole firmamental Creation in its turn be only a corner of some mightier scheme—a larger edition, so to speak, of such a group as composes the Nubecula Major of the South—*a mere Nubecula itself?* Probably COLERIDGE is not in error:—"It is surely not impossible that to some infinitely superior Being the whole universe may be as one plain—the distance between planet and planet being only as the pores in a grain of sand, and the spaces between system and system no greater than the intervals between one grain and the grain adjacent!"

But let us not go on to bewilderment. Apart from considerations of Space and Time, we know this fact, that we are in the midst of Being, whose amount, perhaps, we cannot estimate, but which is yet all so exquisitely related, that the perfection of its parts has no dependence upon their magnitude,—of Being, within whose august bosom the little ant has its home, secure as the path of the most splendid star, and whose mightiest intervals—if Infinite Power has built up its framework—Infinite Mercy and Infinite Love glowingly fill, and give all things warmth and lustre and life—the sense of the presence of God!

PART II.

THE PRINCIPLE OF THE VITALITY, OR OF THE INTERNAL MECHANISM OF THE STELLAR CLUSTERS.

LETTER IV.

PROBABLE UNIVERSALITY OF PLANETARY SYSTEMS—RELATION OF NEIGHBOURING STARS TO EACH OTHER—OPENING OF THE QUESTION.

Returning homewards, through those profound abysses, to whose extremities we have adventured, and leisurely surveying the objects whose number and varieties struck us at first with an absorbing and most natural astonishment, we soon start the inquiry, *What are these clusters doing?*—What is their internal condition?—What their mechanisms?—And why are they located as they are? It is manifest, that such investigations, in so far as we would rest them on observation, must begin at least with our own cluster;—the telescope, which has revealed the dim lustre of others, having only discriminated their outward forms, and still failing to distinguish the peculiarities of their individual orbs; but if we analyze the system of which we form a part, and become familiar with the mode of *its* existence, a cautious use of the argument from analogy, will perhaps darkly illumine the obscurer objects which surround it.

I. In the first place, it is of importance to ascertain whether the stars are individually characterised by the same leading features; or—taking our SUN, which we know best, as a pattern object—whether and how far the distinct orbs of remote space may be accounted to resemble him? The old notion that these luminaries are of no significancy, except as ornaments to the earth, has lost hold, I believe, of all classes of minds; so that, assuming what the preliminary astronomy has taught us—that the stars are also suns, shining like our luminary, of their own perennial virtue, we may step at once to consideration of a new or next higher point of probable resemblance. It is singular, that the first class of stellar changes, by which the attention of astronomers was arrested, seems to refer to one interesting relationship—the consequences of which extend farther than at first sight appears. A number of stars have long been known to vary in lustre—increasing to a certain degree of brightness, and then waning to a certain degree of faintness—a variation found to be *periodical*, *i. e.* it takes place *regularly*, and within a definite time. The star ALGOL, for instance, varies regularly from the second to the fourth magnitude, and again back to the highest brightness in about two days, twenty-one hours; the second star in the Lyre, goes through a periodic variation in six days nine hours; a star in the Swan varies from the sixth magnitude to absolute invisibility, and from that resumes its original brightness in eighteen years; and the following table exhibits the course of similar changes in others of the celestial bodies*—

* I am not certain whether another phenomenon ought not to be ranked with these variable stars. We have now seven or eight authentic records of the sudden appearance, and subsequent extinction of new and brilliant *fixed* stars—splendid orbs bursting from the bosom of infinity, and after blazing for awhile, retiring slowly into their unknown remotenesses. This phenomenon has once or twice been manifested so suddenly, as to strike the eye even of the multitude. One of the most remarkable instances occurred to Tycho, the illustrious Dane. On the 11th November 1572, as he was walking through the fields, he was astonished to observe a new star in the constellation Cassiopeia, beaming with a radiance quite unwonted in that part of the Heavens. Suspecting some disease or delusion about his eyes, he went up to a group of peasants to ascertain

Names of Stars.	Periods of Variation.			Degrees of Variation of Magnitude.	
	Days.	Hrs.	Min.		
δ Cephei, . .	5	8	37	3.4	5
η Antinoüs, .	7	4	15	3.4	4.5
α Herculis, .	60	6	0	3	4
o Ceti, . . .	334	21	0	2	0
χ Cygni, . .	396	0	0	6	11
367 Hydræ, . .	494	0	0	4	10
420 Leonis, .	Several years.			7	0
κ Sagittarii,	Several years.			3	6
ψ Leonis, . .	...			6	0

if they saw it, and found them gazing at it with as much astonishment as himself. He went to his instruments, and fixed its place, from which it never afterwards appeared to deviate. For some time it increased in brightness—greatly surpassed Sirius in lustre, and even Jupiter; it was seen by good eyes even in the day-time, a thing which happens only to Venus under most favourable circumstances; and at night it pierced through clouds which obscured the rest of the stars. After reaching its greatest brightness, it again diminished, passed through all degrees of visible magnitude, and finally disappeared. Some years after, a phenomenon equally imposing took place in another part of the Heavens, manifesting precisely the same succession of appearances. We are quite baffled to account for these astonishing displays. If the bodies in question are moving in orbits, how singular, that no change of position was observable, and how tremendous the velocity which could sweep these suns in so brief an interval from a region comparatively close to us, to the invisible depths of the Heavens! Some ground of probability is furnished by a comparison of records, that the star seen by Tycho is not a

This variation has also been recently much observed in a number of stars in the immediate neighbourhood of each other—so near, indeed, that the naked eye mistakes them for one single star—whence their usual designation, viz. the *Double Stars.* In a very striking object of this description—γ Virginis, whose constituents are equal at certain epochs, there seems a periodical variation in the light of *each* star, as if each in turn presented a dimmer face to us, or were alternately obscured by intervening opaque bodies. There are at least 23 similar conjoint bodies in which such variations appear; and of these, besides γ Virginis, I must especially note ϵ Arietis, ζ Bootis; 38 Geminorum; 48 ι Cancri, &c. Variation is *suspected* in upwards of 40 others, so that the phenomenon is by no means a peculiar or limited one, but connected, in all probability, with important arrangements in the economy of our firmament.

Discarding every hypothesis which rests upon

stranger, but one which appeared before, passing through its mighty phasis in about three hundred years. If this be true, it ought to reappear in forty or fifty years from the present date, when, by due study, something concerning the yet strange system of phenomena it exemplifies, will probably be brought to light.

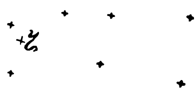
no analogy with known facts and changes, there are only two accessible explanations of these still mysterious and little-explored changes.—Inasmuch as the *position* of these stars in the Heavens is wholly unaltered during their recurring changes, we cannot rationally attribute to them an orbitual motion, or explain their varying brightness by varying distance; so that we are reduced to an obvious alternative. Either, as already hinted, dark bodies of considerable magnitude revolve around them, and by their periodical intervention intercept part of their light; or the orbs themselves rotate on axes, and at equal intervals turn towards our solar sphere parts of their surfaces which may be covered with spots, or are otherwise dimmer than the rest. The former hypothesis is captivating, for it would establish at once the reality of other planetary systems upon a scale surpassingly grand; but the very grandeur of this scale, the relative magnitude with which it would require the subservient bodies to be endowed, militates against our best notions of planetary cosmogony; neither does the rigorous *periodicity* of the variations agree with this notion,—for the intervention of the planets or dark bodies would not in such a case be regular or periodical.—The second hypothesis, on the contrary, is in close accordance with established attributes of our own Sun. His disc, owing to the varying number of its *spots*, gives out varying lights; and you will find, in works which enter largely on the question of the phenomena of the solar system, the statement of several grounds of belief, that, besides this periodic variation, there may be *an inequality in the illuminating power of the two hemispheres of his disc*—the one being perceptibly fainter than the other. Now, such being supposed, the sun *must* appear to remote bodies as *a variable star*—his variation being a strict consequence of his *rotation* on his axis; so that the analogy of his constitution clearly favours the hypothesis, that the variation of other stars is referrible to similar peculiarities of constitution, joined to the fact, that they ROTATE likewise. Our reasoning is also identical with what is esteemed quite adequate to establish the rotations and periods of some of the satellites belonging to the more distant planets of our own system. Too distant to exhibit small individual spots on their surfaces, these yet shew a general variation in the light of the discs they alternately present to the earth; and the varying light, whatever its cause, is supposed to demonstrate this alternation of their visible surfaces.

At the outset, then, we have reached the conclusion, that the rotation of the sun upon his axis is no isolated phenomenon, but one partaken of by vast numbers of the other orbs, and indicated by unequivocal appearances; but there is a secondary inference which bestows far higher importance on the tidings sent from these variable stars. Phenomena apparently the most distant are often closely related in the grand scheme of things; and—as you will learn afterwards—the rotation of an orb, and the existence of engirdling planets, are so closely connected, *that the planets may be said to spring out of the circumstance of rotation;* the existence of planets indeed may be almost predicated of *every* case where rotation is detected.—This new problem, however, may soon be withdrawn from the region of surmise, and resolved in separate instances, by the Telescope. Sir John Herschel—a mere hint from whom is of authority—has lately requested attention, in the most express way, to the minute and point-like companions of such stars as ι URSÆ, α^2 CAPRICORNI, α^2 CANCRI, γ HYDRÆ, $\varkappa$ GEMINORUM, &c. as in some of the cases probably shining by *reflected* light. If these small silvery points—lurking within the rays of their respective suns, should indeed prove to be planets, the telescope will have performed the greatest of its achievements; and if, upheld by observation as far as it can stretch, our knowledge of the physical constitution of matter shall ever enable us to state it as a general and necessary law, that all the orbs of space—not merely those which shine above us, but also the myriads whose wonderful clustering is seen in distant firmaments—that each one of this mighty throng, is, through the inseparable exigencies of its being, engirt by a scheme of worlds—proud as ours, perhaps far prouder;—how immeasurable the range, how illimitable the variety of planetary existence! No wonder that our small world—a mere nook in space—an infinitesimal item of that mighty whole—should be incomplete and fragmentary, silent concerning the interior of many phenomena which are developed in it, and containing few illustrations of much which we desire to know of the fundamental conditions of Being. The Great Book of the Universe—that which explains the labyrinth and leaves no enigma, deduces its easy expositions from the premise of the *perfect* Universe: the few stray leaves of this book which have reached terrestrial shores, must seem sibylline, often incoherent—speaking of laws which enter among visible arrangements only by their lateral actions, and whose roots are down, far from present sight—deep in the bosom of that all-encompassing Wisdom which comprehends the entire system of things.

II. Having obtained this gleam of evidence—albeit nearly evanescent—that the suns of space are also the central luminaries of great planetary trains,—we drop for the moment all thought of planets, and proceed with the more daring questions:—*Are the different suns isolated or related? Does our sun, and every other orb, retain its place, its constitution and character, independently of its neighbour? Or, as with minor arrangements, is there here also—even in the great vault—some intimate connexion, some network whose refined tracery may be pursued?* A train of discovery has followed from these inquiries, which might be the distinction of any epoch, and which constitutes the proudest title of ours to be ever illustrious in Astronomy. I shall unfold the subject by ascending through the different orders of known relationships.

It has been observed, at least since the time of Galileo, that while the great majority of the stars in the Heavens appear somewhat equally distributed, and therefore at medium or average distances from each other; there is a large class which exhibits peculiarity of arrangement in this respect, evincing a greater degree of proximity than the hypothesis of equal scattering will account for. The more remarkable of these neighbouring stars are so close, that they cannot be separated by the naked eye, but appear as a single star, until analyzed and divided by good telescopes; * and to such objects

* These objects are exceedingly beautiful, and fortunately some of them may be decomposed by telescopes of ordinary power. There is one in the constellation of the Great Bear, which a common glass will separate; it is the star ζ. Even to



the naked eye ζ appears double, but that is not the phenomenon. It is the *larger* of the two, which may be decomposed, and to which I refer you.

about the close of last century, Sir William Herschel happened to give especial attention, in the hope of resolving by their means, the problem which proposes to determine the distance of the stars, by noting the amount of their apparent displacement, when viewed from opposite ends of the Earth's orbit. At that time the unusual proximity of such bodies was accounted for by supposing that they lie in almost the *same visual line*, or that their apparent proximity is *optical*, not *real;* one star being imagined far behind the other, and divided from it by not less than the wonted interval—but seen or nearly in union with it, because the two are in very nearly the same direction. In his earlier papers Herschel assented to this hypothesis, but he quickly discerned its fallacy, and foreboded in these stars a significancy far more profound, which he afterwards evolved by a process of ratiocinative observation of the most pregnant kind, and which is still one of our most brilliant examples of philosophic inquiry into the remote unknown.

Knowing the approximate number of stars belonging to each magnitude, it is easy to see that we may calculate also approximately how many, or at least what *proportionate number of* *the whole*, should be placed—the one so nearly behind the other, that both stars would appear to the observer as if within a certain distance of each other in space. Were there, for instance, in existence only fifty, or a hundred, or a thousand, of these celestial bodies, placed at different depths in space, it is clear they would seem strewn over the surface of the skies very sparsely, and by no chance could one be expected to be immediately or even nearly behind another. Augment the number of stars as far as that recorded in our maps, and the probability of one or more cases of *optical* proximity will unquestionably be increased; but if they are less numerous than would render large apparent intervals between individuals *uncommon*—which only happens in the Milky Way—the occurrence of these optical conjunctions must still be comparatively rare. But the apparent conjunctions I refer to, are not rare; on the contrary, they are very numerous. The telescope reveals vast numbers of shining bodies in each other's immediate proximity; and since this cannot be accounted for by supposing that the proximity is merely *optical*, or that it arises from the fact of one star fortuitously lying far behind the other, and nearly in its visual line, we are constrained to infer some new law, some ARRANGEMENT among classes of stars, distinguished in all likelihood by phenomena formerly unknown, and of which this unexpected proximity is the external index.*

From this brief explanation, it is manifest that we are approaching arrangements different from any thing previously detected in the heavens;

* The argument may be familiarly illustrated as follows:—Suppose a number of peas were thrown at random on a chess-board, what would you expect? Certainly, that they should be found occupying irregular or random positions; and if, contrary to this, they were, in far more than average numbers, arranged by *twos* on each square, it would be a most natural inference that here there was *no* RANDOM *scattering;* for the excessive prevalence of the binary arrangement would indicate forethought, design, *system.* "Casual situations," says Herschel, on the strength of the principle thus illustrated, "will not account for these multiplied phenomena; and consequently their existence must be owing to *some general law of nature.* Now," he continues, "as the mutual gravitation of bodies toward each other is quite sufficient to account for the union of two stars, we are authorized to ascribe such combinations to that principle." You perceive he has at once reached the fact, that a double star is not always *one star seen behind the other*, but for the most part two stars in actual proximity—in *systematic and regulated union;* and in the fullest confidence in that ORDER which pervades all Nature, where every arrangement has a cause and meaning, he has also asserted that this union *subsists through energy of some general law.* We shall soon see that it needed little more to enable him to foreshadow a memorable truth.

and the probable extent of the field to which the discovery so opened will introduce us, may be ascertained by a few calculations, which I will arrange in tables. They represent the actual numbers of stars found in close proximity, and contrast them with the very few which might be expected to be only optically conjoined.

First, however, let us attain some easy but clear notice of the amount of the small quantities of which I am about to speak. If the whole circuit of the heavens were divided into 360 equal parts, each of these parts would be termed a *degree*. If one of these degrees were subdivided into 60 equal parts, each of these parts would be what is termed a *minute*; and if a minute were again subdivided into 60 equal parts, each of these very small parts would be a *second*. Now, the distances we have to deal with are expressed in seconds, and they are so small that it will cost you no little difficulty to apprehend their real or comparative sizes. One fact may be of assistance. The diameter or breadth of the sun is nearly 2000 seconds, so that if we suppose that breadth, as it appears to the eye, to be divided into 2000 equal parts, one of these parts will be about the size of one second, two of them that of two seconds, &c.*

For the sake of convenience, the approximate or conjoint stars are divided into *orders*, determined by the distance of their constituents. The first eight orders include all bodies within 32 seconds of each other, *i. e.* not separated from each other by so much as the apparent breadth or diameter of the planet Jupiter. These are essentially double stars, *i. e.* they appear single to the naked eye, nor can the nearest of them be separated without the aid of the finest telescope that art has yet produced.—The subsequent tables will now, I hope, be understood without difficulty. The one first presented contains all the double stars, from the Pole to 15° south of the Equator, in which neither constituent is very much less than the least we can discern with the naked eye; they should be easily seen, at all events, with a common good telescope. From the care bestowed in the survey, this list must include about the whole of such objects to be found in these regions of the Heavens.

* Degrees, minutes, and seconds, are usually written symbolically.—Thus 10° 11′ 12″, signifies ten *degrees* eleven *minutes* twelve *seconds*.

TABLE I.

Orders.	Distances.	Numbers probably only optically within that distance.	Numbers observed.	Difference of the two former Cols. shewing the No. of really approximate stars.
I.	0″ to 1″	.05	62	62
II.	1 to 2	.14	116	116
III.	2 to 4	.56	133	132
IV.	4 to 8	2.24	170	128
V.	8 to 12	3.73	54	50
VI.	12 to 16	5.23	52	47
VII.	16 to 24	14.94	54	39
VIII.	24 to 32	20.91	52	31
Sums,		48	653	605

From this table we deduce the important fact, that so far from the principle that these conjunct stars are optically double—*i. e.* that they appear near, because of the sameness of the directions in which they lie—so far from that principle being able to explain the whole existing arrangements, it accounts for the proximity of no more than 48 sets out of 653—leaving 605 to be explained by some other law, and to stand forth—as they emphatically did to the philosophic mind of Herschel—the indices of unknown and profound design! The next table refers to stars whose small companions are of much less magnitude, and of course only includes those of which we have already *complete* lists. The distances corresponding with the orders are the same as above.

TABLE II.

Orders.	Numbers optically double.	Numbers observed.	Numbers really double.
I.	1	16	15
II.	3	82	79
III.	11	176	165
IV.	43	214	171
V.	71	124	36
Sums,	129	612	483

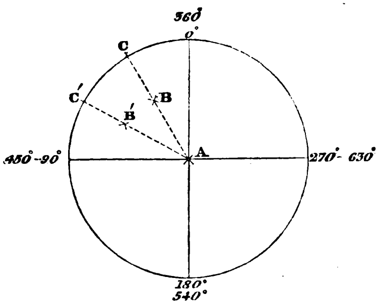
In other words, of 612 conjunctions among the smaller and more numerous stars, there are 483 unaccounted for by the notion that the proximity only indicates that one star is far behind another. STRUVE, in the introduction to the Catalogue from which we derive our details, has pursued the inquiry to its apparent limits—*i.e.* until he reaches the distance at which the probability of the *conjunction being solely optical*, undoubtedly prevails. The following table, containing complete lists of the *brighter* stars only, gives his conclusions.

Orders.	Distances.	Numbers probably optically related.	Numbers observed.	Numbers physically related.
IX.	32″ to 60″	1.536	15	13
X.	60 to 120	6.439	15	9
XI.	120 to 300	7.74	17	9
XII.	300 to 600	27.56	38	10
XIII.	600 to 900	21.50	25	3.5
Sums,		65	110	44

It cannot fail to be noticed that the number of stars optically related is here much *larger* than in the former table; and in order XIII. nearly the whole are related optically, thus evincing that the limit 15′ or 900″ approaches to the usual or average interval of celestial space between independent stars of the magnitude referred to. The result of the whole may be briefly stated :—*In reference to stars not smaller than the least we see with the naked eye, there is a possibility of the existence of a certain unexplained connection or relationship wherever the distance is within* 15′, *or about half the diameter or breadth of the sun ; when the distance is less than* 5′ *or one-sixth of the breadth of the sun, the probability of such a connection is very considerable, and in almost every instance, whether the stars be large or small, where the distance is less than* 30″ *that* *connection may be predicated with an approach to certainty as near as can be attained on subjects so speculative.* If the word speculative is rightly interpreted by fanciful or hypothetical, I am in error in thus using it; for the foregoing conclusions are as sound and warranted as if they rested on a long induction of actual and known connections. The character of the specific connection we may not, on grounds yet unfolded, venture to assign; but that a connection exists, far spreading and memorable, constituting an important feature among the complex arrangements of our firmament, is sustained by that maxim, which is at the root of all philosophy, that Nature is not capricious, and that analogies, or correspondences, stedfastly indicate some Law, real though unrevealed. It is from the confidence with which he rests on this belief—one inseparable from his being—that the true philosopher derives his powers as a seer. The analogy or group of collocated events, is the bud of mighty truth, whose growth or fulness he descries from afar, and proclaims in words of prophecy its approaching advent.

The force of considerations like the foregoing was not lost upon Herschel. Of all men—with perhaps one exception—who ever adventured into unknown regions of the Heavens, this great Inquirer was most deeply penetrated with an enduring conviction of the all-prevalence of Law, whose characters were first indicated by "collocations;" and he evinced a marvellous quickness and solidity of judgment in interpreting the remotest hints,—a feature—a single line was enough, and he divined the outline of the portrait. Rising in the present instance to the utmost height of justifiable speculation, he inquired if *gravity*, a law already known, would not account for the connection which seemed established, and whether in such a case—the Suns would not, like our planets about their Central Luminary—revolve around each other in definite orbits? Herschel, however, was too sound a philosopher to be withdrawn even by the fascinations of so brilliant a conjecture, from that laborious path which alone can guide to truth; and at the same moment in which he threw out his ideas, he urged Astronomers to confirm or disprove them by observation, exhibiting labours of his own by which, if extended and repeated after long intervals, all mystery would be withdrawn from these singular bodies. Nor did he summon unwilling labourers. I can compare the sensation occasioned in the astronomical world by his discoveries, to nothing save the excitement diffused through Europe when Columbus discovered in the far west, new and mighty continents resting amid the formerly void and mysterious ocean. To follow up his examinations has constituted probably the chief ambition of observers from that time until now. Observatories, with gorgeous appliances, have been carefully suited to that specific purpose; and many private observers have, with their utmost means, toiled in the same walk. Before the close of his earthly honours, the veteran had himself accomplished the measurements, that is—had fixed the places of above 500 double stars. In 1824, Sir JAMES SOUTH and Sir JOHN HERSCHEL produced a catalogue of 380 stars, whose distances and angles of position they had jointly fixed with admirable precision. South followed it up by a distinct catalogue of 480; and Herschel, now also observing apart, has completed a list of upwards of 3300 of such determinations. Inferior to none, however, is M. STRUVE of Dorpat, who, aided by that noble instrument, the Equatorial of Frauenhoffer, first analyzed and afterwards measured the positions of nearly 3000 double stars, with a precision that cannot be surpassed. His last work, which reached this country only a few months since, is thus at once the latest and the classical work on the subject of the motions referred to.—These catalogues, however, do not reach farther than 15° south of the Equator, so that the entire southern hemisphere may be still reckoned a blank—but one destined to be speedily filled, for Herschel has garnered its riches, and will soon convey them to Europe. Nothing was known previously, concerning the double systems of that vast celestial space, except a small catalogue by Mr Dunlop of Paramatta. Allusion to this remote observatory forbids me to pass the name of its founder—himself an able and laborious observer, Sir Thomas Makdougal Brisbane; through whose munificence it was established, and British science made co-extensive with British dominion. Gracefully does the laurel due to such actions adorn the green autumn of life!

My reader will now be prepared to follow the steps of positive discovery in this new and attractive sphere. Astronomers, I have said, undertook to examine and record the relative positions of the stars presumed to be connected, so that they might be compared with distant records made at other epochs. The mode of recording the position is simple. Suppose that a circle with cross diameters, such as the following, were placed in the eye-piece of a telescope, that is, so placed, that both it and the stars should be visible at one and the same time.



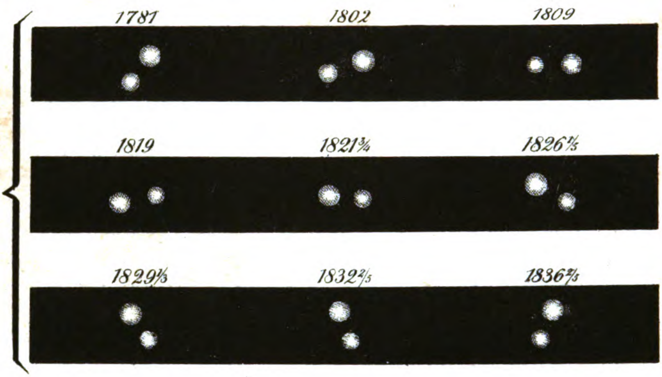
Suppose also that its circumference were divided into 360 equal parts, viz. degrees, beginning at 0°, and passing through 90°, 180°, 270°, to 0° or 360° again, and let the reckoning proceed without interruption to 450°, 540°, 630°, &c. &c. Now, if one of the associated stars be brought to the centre A of the cross lines, the other will lie somewhere else. Suppose it to be at B, and draw a line through A and B to meet the circle in C; this line will clearly cut off the part of the circle between 0° and C, which will contain a certain number of the equal parts spoken of; and if that number be known, the exact distance of the point C from 0° may be laid down in a chart or figure. If B should now change its place relative to A, and, after a certain length of time, occupy the place B′, this change would be immediately detected by the observer, who would find that the line AC′ through A and B′ now cut off a greater number of those equal parts, on a larger part 0°C′ of the circle than formerly. And thus, by noticing carefully the number of degrees, or of equal parts of the circle cut off at all times by the line through the centre of the two stars, their relative changes of position might be clearly ascertained. The distances of the stars, that is the lines AB,AB^1 might also be carefully measured and their varieties recorded. To effect such measurements requires the finest instruments, but art is equal to the task of producing them. The error of the instrument is very rarely so great as the error of the observer in using it.

The instance of ξ URSÆ MAJORIS will illustrate this method of observing, and exhibit an actual *progress* in an associated star. The table below presents the distances of its two stars, measured at different epochs, their angles of position, *i. e.* the quantity of the circle from 0°, cut off by the line joining their centres at the several epochs,—and the names of the observers. We shall experience little difficulty in drawing from it the proper and suitable inference.

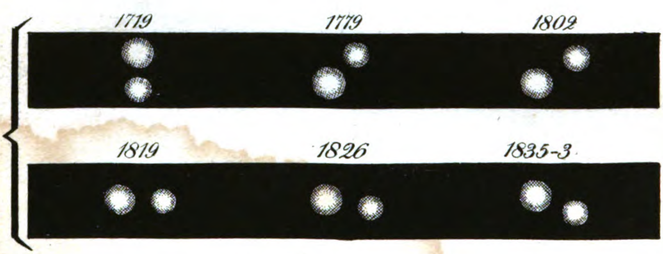
ξ URSÆ.

Epoch.	Portions.	Distance.	Observers.
1781.97	503°.47′	...	Sir W. Herschel.
1802.09	457 31	...	Do.
1809.08	452 .38	...	Do.
1819.10	284 .33	2″.56	Struve.
1820.13	276 .21	...	Do.
1821.13	268 ·48	...	Do.
1822.08	262 .39	...	Do.
1823.29	258 .27	2 .81	South and Herschel.
1825.22	244 .32	...	South.
1825.25	...	2 .44	Do.
1826.20	238 .75	1 .74	Struve.
1827.27	228 .27	1 .71	Do.
1829.35	213 .59	1 .67	Do.
1831.44	203 .82	1 .70	Do.
1832.41	195 .80	1 .75	Do.
1833.38	188 .24	1 .69	Do.
1834.44	184 .10	1 .87	Do.
1835.41	180 .18	1 .76	Do.
1836.44	171 .20	1 .97	Do.

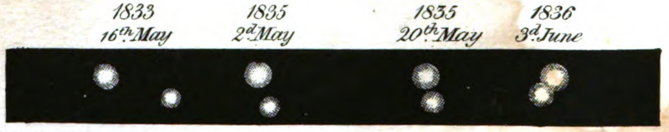
Position of the 2 Stars of ξ Ursæ Majoris *in*



Positions of the 2 Stars of Castor *in*



Positions of the 2 Stars of γ Virginis, *in*



Forrester & Nichol lith.

The recorded distances of the two stars are ambiguous, and perhaps contradictory, but they vary within limits so extremely narrow, that much may be referred to the error of observation. The change of the angles of position, however, is manifest; and, as the foregoing remarks will have convinced you, these enable us to ascertain how the two stars were placed with regard to each other at their respective epochs. Without farther reference to tiresome minutiæ, I shall express these changes to your eye by a plate. In Plate X. the three upper lines contain a representation of the positions of the two stars, as indicated by the previous table, at the epochs marked above them. Observe how the smaller star gradually moves around the other in an orbit! Can any one, on looking at this plate, doubt of the reality of the motion of these orbs? Nor is ξ Ursæ singular. The next two lines represent the positions of the two stars in Castor, which, indeed, vary much more slowly, but are equally indicative of a grand motion of revolution. Lastly, observe the line containing the record of the changes of γ Virginis;—it affords evidence no less emphatic of an alteration of place, intimating orbitual motion; although the period of the stars is still vaster than that of Castor. By means of these diagrams, your reason will be satisfied of the marvellous truth, which all recent astronomy has confirmed. I know it requires no trifling amount of evidence to induce us to accept a phenomenon so novel and so wonderful. If aught in the universe were a landmark, it surely might be supposed to be those stars infinitely remote, deep in peaceful infinity, and undisturbed by the commotions of earth ;— No! neither have these a fixed place : they also are governed by the omnipotent ordination of Activity; and partake amid their apparent profound repose, of that course of change to which all the universe is subject, and which presents to the meditative eye the mightiest shows of Being as only transitory—phases of some scheme of unresting and stupendous evolution !

The question next presses, *In how many* of these approximate stars have such motions been recognised; in other words, of what degree of advancement can we boast in this department of observing astronomy? We again seek the reply in the pages of M. Struve. The following Table presents the whole double stars whose existence this laborious observer has detected, arranged according their orders; and the subsequent columns contain the number which have evinced the certainty of a mutual relation, by the fact of undoubted change.

TABLE III.

Order.	Number of Double Stars in each order.	Number of Stars in which Change is certain.	Change is probable.	Change is suspected.	Sum of Changes.
I.	91	13	4	3	15
II.	314	10	6	5	15
III.	535	12	5	12	19
IV.	582	7	9	14	17
V.–VI.	583	7	9	14	17
VII.–VIII.	535	9	6	18	18
Sums, .	2640	58	39	66	101

The last column is made up, not by taking the *sum* of the three preceding it, but by adding to the third column that *proportion* of the fourth and fifth in which change may safely be assumed. Struve so estimates these observations, that six out of ten in the fourth column, and only three out of ten in the fifth, can be assumed as actual changes. One hundred and one stars out of 2640, are thus all that have yet yielded the secret of the mode of their connection; although our arguments from their proximity establish it as indubitable, that in the immense majority of that large number, connection must exist. But, seeing the date of the observation is only as yesterday, let us not repine at the fewness of the motions ascertained, so much as rejoice that a sure promise remains to stimulate the ardour and reward the industry of inquirers. It is no more than fifty years since measurements of this kind were first undertaken—not more than thirty-six years since the probability of orbitual motion among the suns of space was ascertained by Sir William Herschel; and then, how slow are many of these motions, how rare and recent the instruments capable of following their evanescent variations, how "envious," too, are the "clouds" of Man's too intimate knowledge of the Heavens! But notwithstanding of every obstacle, we have a right to the highest hopes. Not a year will pass without adding some new systems to our catalogue, and long before the lapse of a century, perhaps, the motions of few of these 2640 objects will have escaped the vigilance of the telescope.

The brighter stars observed by Herschel, *i.e.*, those stars whose measurements were taken at the earlier periods, exhibit the changes indicated in the subjoined table.

TABLE IV.

Order.	Number of brighter stars observed by Herschel.	Number of Stars in which			Sum of Changes.
		Change is certain.	Change is probable.	Change is suspected.	
I.	10	8	0	1	8.3
II.	19	7	4	2	10.0
III.	42	9	4	9	14.1
IV.	44	6	5	7	11.1
V.–VI.	34	2	6	7	7.7
VII.–VIII.	28	3	3	7	6.7
Sums, .	177	35	22	33	58.1

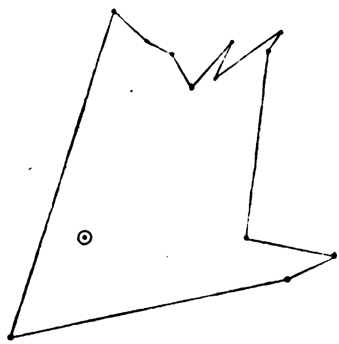
This table is very important. First, it exhibits 58 established systems in a list of 177, which perhaps intimates the proportion of the foregoing 2640, or 880 systems, as the least number we may expect to find established at the end of the next fifty years; for in Herschel's stars there is nothing peculiar, and telescopes are about to be applied to the Heavens, which will bring the smallest bodies, whose positions are now recorded, within the class of bright stars. It is however remarkable, besides, that *the greater number of changes are observed in stars belonging to the first orders;*—the very first order, which includes objects whose constituents are no farther separated than one second, yielding 8.3 systems out of 10. This fact can be accounted for only on the supposition, that the stars *apparently* nearest move with the greatest velocities, and that the velocity diminishes and becomes more difficult of detection as the apparent distance increases; and, inasmuch as the planets *actually* nearest the sun move with much greater rapidity than those more remote, we infer that the pairs of stars which *seem* to be nearest are so *in reality;* and that, with a few exceptions, their comparative proximity is not owing to their remoteness from our sun. Struve deems the truth now announced of great importance, and he has embodied it in the following proposition:—"*The division of the double stars into orders, according to their mean distances, does not rest on mere appearances. Stars of the first order, distant from each other from* 0 *to* 1″, *are generally those whose actual linear distances from each other are the least; and the same holds good in the case of the other orders. Wherefore, the nearer* *the stars appear to each other, the more intense is the action of gravity by which they are retained in conjunction, the more swift do they move in orbits around the centre of gravity, and the less are the periods of their revolutions.*"

It is now time to state in distinct and emphatic terms the grand truth, with which these researches on approximate stars have enriched astronomy. I have already unequivocally shown that the study of these conjunct bodies involves the wonderful phenomenon of one sun revolving around another; and there cannot be a doubt that *all* the changes whose discovery I have narrated so fully, exhibit the same thing, viz. the motion of one individual of each pair, through a certain part of an orbit. No part of the subject is left in doubt, as at least four systems have *completed their courses* since observation began, and yielded not only their periods, but the *special nature of their orbits.** These four are the following:—

* The nature of the curves or paths in which the bodies move, establishes an important general truth. At first sight, it seems easy to detect these paths, the problem simply requiring that we set off distances from the central body, corresponding to each angular position. Unfortunately, however, we cannot depend upon recorded observations of distance; the slightest error vitiates the whole, and more than slight errors have been

η Coronæ	revolves in	43	years.
ζ Cancri	......	57	...
ξ Ursæ Majoris	... ..	61	..
p Ophiuchi	......	80	...

committed in such estimations. For instance, the star *p* Ophiuchi, would, if so judged, have an orbit like the following,



through which no imaginable continuous curve could pass. There is a supreme necessity for the rejection, *in toto*, of recorded distances, and that reliance be placed on the angles of position alone. Acting virtually on this plan, Savary evolved, by a long but ingenious analytical process, the orbit of ξ Ursæ, and Professor Encke of Berlin applied similar methods to the case of *p* Ophiuchi; but the honour of summarily overcoming the whole difficulty—of giving a general and pliable method, distinguished no less by its facility than by its extreme beauty, by which the required curve may be charted, even from partially erroneous elements, is due to Sir John Herschel. Young geometers, as an exercise of taste, ought to study his memoir; and cultivators of any department of experimental physics, will find in it sources of unexpected power. The curves, as Sir William Herschel predicted, are *elliptical; i. e.* the one star moves around the other, in every case (or, more properly, Three more have been watched with sufficient assiduity to justify astronomers in assigning their approximate courses, viz.

σ Coronæ revolves in		200	years.
Castor,	......	215	...
γ Virginis	......	513	...

Other periods, also, have been conjectured, on grounds, however, more than questionable; nor is the straining of computation necessary, inas-

each around their common centre of gravity), in an oval or elliptic curve—*precisely the curve which is described by the Earth and other planets in their revolutions around the Sun; the law of the velocities likewise is the same in both cases.* Uniformity of this sort is exceedingly remarkable—*it points to some common cause;* in other words, to the LAW OF GRAVITATION, which the nature of this curve enabled Newton to detect as the first principle of planetary order. Gravity has often been surmised to be universal; at all events, we have now stretched it beyond the limits of the most eccentric comet into the distant intervals of space. Every extension of its known efficacy manifestly increases, in accelerating ratio, the probability that it is a fundamental law or principle of matter; but although it should somewhere fail, it is still a type of the *mode* of the constitution of things;—it will lose its universality only through the preponderating efficacy of still profounder powers. Judged in this true light, the vastness of Creation is comprised within a mighty plan; and we, standing on this little world, can gaze around on its majesty, and note its stupendous changes in peace—knowing that there is no hazard or caprice in Mutability, but only the stern and stedfast power of Law, through which events roll onward to their destiny.

much as the foregoing instances, distinct and indubitable, establish that general law which patient inquiry will yet extend through all the vast classes of conjunct stars. How wide that field of novel contemplation opened by these brilliant discoveries! How strange the notion of mighty orbs revolving around each other in less periods than that which Uranus occupies in encircling our sun! Are these revolving suns also accompanied by planets? The fact of *rotation* on their axes appears established among many of them, by their periodic variations of light; and if, as before asserted, rotation involves the idea of engirdling planets, around these double suns planets will unquestionably roll—obeying perhaps both, and drawing from both, light and the conditions of their wonderful life! It is when one goes into regions so new and remote that the character of the Universe, in its majesty and infinite variety, appears in its most striking attributes. In search of magnificence, it is true, we need not wander far,—witness the fields which encircle your home, the blade of the modest grass which adorns them; but those Heavens are *fresh*, and familiarity has not left its footprint on their untrodden floor. In the silence of midnight, that noble curtain stretched out above me, and the idea present and impressive, of its great orbs obediently pursuing their stupendous paths, I confess there is a solemnity which sometimes falls upon the spirit, not unlike the feeling of the Patriarch, when he heard that still small voice, and knew it to be the presence of God!

The course of discovery will doubtless greatly enlarge our knowledge of such periods and orbits; though perhaps there may be sufficient similarity in the most of them to render them in a great manner devoid of individual interest; but from this we must except two classes of stars which promise to afford subject of very engrossing contemplation. Struve correctly remarks, that of all the orders, the *first* is that in which rapid discovery may be most confidently expected, because it is only by telescopes now coming into use that stars so very close can be decomposed or measured with requisite accuracy; and on the ground of the proposition announced at the close of the last paragraph but one, he considers that these very close pairs will yet manifest many instances of revolutions accomplished in much shorter periods than that of even η Coronæ. His great work has laid the foundation for large advances in this field; it has already afforded ground of conjecture that ζ Herculis has a period not exceeding fourteen years, and that 42 Comæ Berenices, γ Coronæ, and τ Ophiuchi, have likewise very brief periods. While referring to these indications of rapid and restless activity among the most majestic bodies of our firmament, the Astronomer expresses his pious gratitude that he has had patience and vigour for the pursuit of them, and that his eyesight is unimpaired. It will be the universal wish of Europe that in the labours of the splendid Observatory, to which his hopes now point, these blessings be preserved to him; and that the fates of Uraniburg never darken the history of this second instance of the noblest institution the world has seen,—dedicated to Astronomy by Imperial munificence!

The other class I have alluded to, as likely to afford results of singular interest, lies at the opposite extremity of the scale of orders. I have shewn that stars so far separated as 15′ or 900″ from each other, are still within the *suspicious* distance, *i. e.* that probably a few pairs so situated are physically connected and form systems. This information is of itself so vague, that perhaps few observers would be disposed to watch and measure all such stars, in the hope of detecting these few; but fortunately another principle enables us to select the actual pairs, to point out many specific sets, of whose connection we are certain, although their motions are yet unrevealed. The principle is this:—A great many stars have what are termed *proper motions* in space, *i. e.* they are slowly shifting their places in the sky, moving regularly onwards by small annual quantities—quantities which vary with the stars—in what as yet appear straight lines, but which doubtless are small portions of vast curves. It happens, that amid all this variety of motion, *both the constituents of* a great number of stars, *optically* connected, partake *equally* of such motions; that is, the one star moves annually in the same direction as the other, and by precisely the same quantity; and how infinitely small, how inappreciable is the probability that they would do this were they only optically connected? True, stars may exist separated from each other by gulfs of space, which have proper motions that would appear the same when viewed from the earth; but considering the immense variety of these motions—how trifling the chance of pairs of such objects being frequently found nearly in the same line? This chance, rightly estimated, is much smaller than that which depends upon the mere position of the stars; and the conclusion is therefore necessary, that when an identity of proper motion is detected, these two stars—suspicious on other grounds—are *certainly connected physically*; their systematic character being the cause of the identity of their proper motion. Now a considerable number, far separated from each other, are thus demonstrated to be systems; among which I distinguish the following:—

Castor, and a third small star,	constituents	distant	72	seconds.
40 Eridani,	...	...	84	...
Regulus,	...	...	180	...
ι and 5 Lyræ,	...	...	210	...
θ^2 and θ^1 Tauri,	...	...	336	..
36 Ophiuchi and 30 Scorpii,	...	...	720	...
Mizar and Alcor,	...	...	720	...

Between these two last stars, Mizar (ζ Ursæ Majoris) and Alcor, a small star of the 8th magnitude, is interjacent, which does not partake of their proper motion. It is impossible to reflect on systems constituted by orbs so far apart as these, without expending a moment of wonder on the periods which must be occupied in their revolutions. If τ Ophiuchi, or ζ Herculis, surprise us by their rapidity, and consequent restless activities; systems like the foregoing astonish by the durations through which they hurry the imagination. Observation, of course, can alone determine their actual periods, but by a simple artifice we may reach a conception of what they are. By the laws of motion we can calculate what would be the period of any star whose present period and distance we know, were its constituents as far asunder as these others are. Taking *p* Ophiuchi as our standard, whose present period is 80 years, and its distance 4.″33, we find that if its two stars were separated as far as those in 40 Eridani, their period would occupy more than 7000 years, and that, were they at the distance of Mizar and Alcor, it would stretch over no less than 190,000 years! Such, then, or some such, is the period in which Mizar revolves around Alcor,—a period which is the *unit*, the *single year*, of that stupendous system! Our small units, one hundred and ninety thousand of which are thus compressed into one single unit of a vast system, may serve to reckon the days and months of human life—the duration of royal houses—the periods of empire;—to measure the surface-changes even of our own globe, they have been found inadequate—how, then, shall we extend them to the skies, and attempt to read by their puny aid those celestial annals, which must be divided according to numbers of their own?

I have lingered not unwillingly among these gorgeous fields, but the space already occupied warns me that it is fitting to close. One other point, however, connected with these pairs of suns, is so singular, that I anticipate your pardon though you are detained a moment longer—I allude to their *colour*. It has long been observed that the stars shine with different colours; for the diversity is apparent to the naked eye. Among those of the first magnitude, for instance, Sirius, Vega, Altair, Spica, are white, Aldebaran, Arcturus, Betelgeux, red, Capella and Procyon, yellow. In minor stars the difference is not so perceptible to the eye, but the telescope exhibits it with equal distinctness. It is likewise far more striking in countries where the atmosphere is less humid and hazy than ours; in Syria, for instance, one star shines like an emerald, another as a ruby, and the whole

Heavens sparkle as with various gems.* Now, this attribute of variety of colour distinguishes also the double stars, which, indeed, was to be expected; but the *association* of these colours presents a new and remarkable phenomenon. Struve records that, in at least 104 binary systems, the two stars exhibit the *complementary* colours, that is, the colour of one constituent belongs to the *red* or least refrangible end of the spectrum, while that of the other belongs to the *violet* or most refrangible extremity,—as if the entire spectrum had been divided into two parts and distributed between these two companions.† An opinion prevailed lately that this phenomenon is the mere effect of contrast, or of an optical delusion depending upon the well known law that when the eye has looked for a time on one bright light, it is inclined to clothe any smaller light near it, with the oppo-

* There is no doubt that, in the course of long periods of time, stars change their colours. Sirius was celebrated by the ancients as a red star, now it is brilliantly white; and other changes have occurred of a like nature. It were more than vain to speculate regarding the causes of these variations. They are indicative of a set of laws whose nature is yet wholly unknown.

† May this distribution not be used as another argument in behalf of the physical connection of the stars? Does it not darkly intimate a common origin? See part third of our work.

site or complementary colour, for the sake of relief. Abstractly, the explanation is plausible, but it will not endure the test of facts. In the first place, the law, if true, ought to be universal; whereas we find many systems similar in relative magnitudes to the contrasted one, in which *both* stars are yellow, or otherwise belong to the red end of the spectrum. Secondly, if the blue or violet colour were the effect of contrast, it ought to disappear when the yellow star is hid from the eye. Now, Struve refers to the three stars composing 0_2 Cygni. The larger is of the fourth magnitude and intensely yellow, while the others of the fifth and sixth magnitudes, are blue; and *though the first be hid, these two preserve their blue colour*. The double star β Cygni affords, in my opinion, a still more emphatic confirmation of the truth; indeed, I marvel how an observer who has seen these stars blazing, one with its yellow, the other with its intensely blue light, could have encouraged the optical hypothesis for one moment. The constituents of this star are considerably apart, and may be separated by an ordinary telescope. By means of a thin slip of darkened brass or copper, hide the one star, and note the colour of the other. If the yellow star be hid, its companion loses nothing of its peculiar splendour; and if you observe the blue star, the other radiates precisely as before. Whatever the origin then, of this mysterious power, on the part of such binary stars, to divide as it were the light; or however it may be connected with the process which brought the systems into being,—no shadow of doubt of its *reality* remains. And think of the novelties, the peculiarities, which the existence of double and party-coloured suns cause to the planets encircling them! "It may easier be suggested in words," says Sir John Herschel, "than conceived in imagination, what a variety of illumination two stars—a red and a green, or a yellow and blue one, must afford a planet circulating around either; and what cheering contrasts and grateful vicissitudes, a red and a green day for instance, alternating, with a white one and with darkness, might arise from the presence or absence of one or other, or both, from the horizon!" All the products of the material constitution of this earth, the character of its living families, perhaps the action of its magnetic and other influences, are co-ordinated and adjusted to the regular succession of night and day, or to the supply and nature of our solar light. No such families then, none bearing other than remote analogies to ours, can exist in planets, engirdling such double suns. They, too, are surely the abodes of beauty and harmony, but their features are hidden from man—perhaps for ever. And who after all would grieve although there be some enclosed spots—quietudes, in Creation, which will be unexplored, unpenetrated for ever; who that has felt the soft healing of Evening, can regret that, even in the intellectual world, there are regions into which faintness and weariness may sometimes flee, and take shelter and repose, away from the scorch and glare of oppressive light! Sweet and inviting mysteries—among whose gentle shadows Hope and Fear, and all unnamed yearnings, tremblingly advance, and find or fashion for themselves images of purity, convictions of immortality, vistas of a long life to come, through which the soul may wander freer and greater than now, "having gained the privilege by virtue!"

LETTER V.

TRIPLE AND MORE INTRICATE COMBINATIONS—EXISTENCE OF LARGE GROUPS—CONJECTURES RESPECTING THE FORM AND DISTRIBUTION OF CLUSTERS.

ENCOURAGED by the signal success which has attended our investigation of the binary arrangements, whose phenomena we have just unfolded—we advance cautiously, but without dread, to take cognizance of still higher schemes. The arguments which induced Herschel to pronounce on the connexion and motion of the constituents of the simpler systems, penetrate much farther, and intimate as a general law, *that every cluster or unusual aggregation of orbs must be systematic, and probably united by common motion.* If it is unlikely that the principle of random scattering would produce numbers of close PAIRS, it is still more unlikely that TRIPLE or QUADRUPLE BODIES should originate in fortuitous optical positions; and the presence of a great law thus lays it on astronomers as a command that they watch these higher systems, take their measurements with every minuteness, and transmit them to posterity.

The occurrence of triple stars or of approximate conjunctions of three, is much rarer than that of Pairs, but still we find numbers sufficient to excite a profound interest. Struve has specified 11 sets of bright triple stars, that is of conjunctions of three bodies, within the space of 32″, and none of which is too small to be seen with an ordinary telescope (none being smaller than *his* 8th magnitude); and of these 11 the calculation of probabilities will not permit us to suppose that more than one system owes its character to mere optical proximity. Systems of three suns connected by the physical law of attraction, and revolving perhaps round their common centre of gravity, are thus at once brought upon the scene. In another list our astronomer records 57 more within the same distance of each other, but in which one attendant belongs to the class of smaller magnitudes,—a list containing likewise, without doubt, many physical systems ; and in a third series of 59 similar combinations, not confined, however, within the limits of 32″ of distance, he exhausts our present knowledge of the subject. The results of the future and laborious examination of these systems are already foreshadowed. The double star ζ Cancri, which performs its binary revolution in a retrograde direction in 57 years, is accompanied by a small companion in which motion has been seen, and which, if, as is unlikely, it continued to perform its whole path with its present velocity, would accomplish a grand orbitual motion in about 600 years. Nor is ζ Cancri the only combination whose phenomena have realized our most sanguine expectations. In the three stars of ξ Libræ, the two nearer have performed half a revolution in 54 years, intimating 104 as their probable period; and the third has in that time moved in *the opposite direction*, only about the twenty-fifth part of an entire circle. Motion has been suspected also in the triple star ψ Cassiopeiæ, but confirmation is here wanting. We can however, as before, deduce from the *com-*

mon proper motion of several double stars and their companions, the necessary systematic connection of various groups not yet observed to change. For instance Castor, and the small star near it, must be a triple system; whilst 36 Ophiuchi (a double star of short period) and 30 Scorpii on the one hand, and Mizar (also double) along with Alcor, on the other, constitute related schemes upon the grandest scale. Is it wonderful, with these prospects in the distance, that multitudes of enthusiasts are crowding into the service of Astronomy, and peers and princes vying for honourable notice in the science, by acts of costly patronage?

Passing from triple to yet higher combinations, we find every thing to hope. Near the brilliant star α Lyræ, a good eye discerns a star of a somewhat irregular or elongated form. When viewed through a telescope, this irregularity is explained, for the star separates into two ϵ and 5 Lyræ, distant 219″ from each other, which also, by the test of their common proper motion, we know are physically connected. Now each of these two stars is itself double, constituting a scheme like this

—a quadruple scheme, in which A will revolve around B, C around D, and perhaps both double systems, nicely balanced and harmonised around some intervening point. If we revert to our supposed law of necessary planetary existence—if the orbits of dependent worlds are intertwined around these four luminaries, we must indeed have strange systems in space, and mechanisms of a complexity which compels our boasted powers of analytical calculation, to confess themselves in the very infancy of progress!

Among Struve's first list of eleven physical triple stars, we find θ Orionis—a star which, fully examined, turns out quintuple, or composed of five constituents so closely placed, that this distinguished astronomer declares them, without scruple, to be all conjoined by the force of attraction! This star is the celebrated trapezium in the nebula of Orion, and it seems that motion has been observed in it. Until Struve obtained the Dorpat telescope, only four stars had been seen in this beautiful cluster; but he had hardly examined it until he discovered the fifth. He lost no time in communicating the discovery to Sir John Herschel, who confirmed it with his twenty-feet reflector, stating besides, that, if the star had been previously visible, he could not have missed it on occasion of his sketching with great care that outline of the Nebula, to which I will soon have occasion to refer. It has been said that the little stranger has again disappeared, having gone, probably, to a remote part of its orbit: — the disappearance, however, is still apocryphal. Does the lost Pleiad—the sorrowing Merope—refer, after the fashion of that beautiful mythology, to a similar phenomenon, the retirement of a star formerly visible? The Pleiades must be connected and bound by mutual relations. In Harding's Atlas, we find in that constellation 1 star of the fourth magnitude, 6 stars of the fifth, 5 of the sixth, and 32 of the seventh—in all 44 stars within a circular space of the radius of one degree; and the probability of their merely optical connection is measured by the almost evanescent fraction $\frac{1}{4409 \times 10^{50}}$!— These are but glimpses of what an analysis of such celestial collocations will yet reveal; but one's satisfaction in their contemplation is almost damped by reflection on the time and labour still necessary to explore them. On referring to the field they open—to the little hitherto accomplished, compared with what remains to be done—to the deep mystery still hanging over almost all the skies—there is apt to supervene a despondency, a hopelessness that the handwriting which is on them, will ever be interpreted. But we take encouragement from the aspects of the times. Astronomy is not now in that stage of its history in which only a few men in a century would consent to wear out a long and healthful age in examining the Heavens. Observers of the first capacity and becoming ardour, are yearly multiplying; while adequate instruments, through the advance of Art, grow more accessible. Doubtless, with all advantages, we, of this time, may do little more than roughly chart the boundary lines, and it may be, fix down the prominent points of the landscape;—the filling up and mapping of the details constitute the harvest of the future. But how soon may that future come! The wheels of time are revolving rapidly—truth mingling with truth, as light gathered into a focus. Alike within and around us, events succeed without the usual interval, nor is astronomy unaffected by the general acceleration. The knowledge of what the Heavens are boding may not be long deferred; if we, in present times, industriously act our part, much still unintelligible will become plain to the generation whose buds at this moment are the spring tidings of the world—the generation now pressing on us, and to which we must yield the stage.

But our reasonings from probability extend much farther than to minor or small collocations and clusters within our firmament; and reveal certain grand though still subordinate modes of activity to which the firmament itself must be subject. On looking at our vast bed of stars, we find marks in many parts of it of striking peculiarity, and indications of system which it is impossible to overlook. It seems to consist of two great portions, in so far isolated, viz. the Ring or Milky Way and central mass (See Fig. 1. Plate III.); in each of which some subordinate system must reside. We know little of the constitution

Pl. XI.

Pl. XII

of the [illegible]

[illegible]

The Re[illegible]

rather a su[illegible]

parated from [illegible]

[illegible]

[illegible]

[illegible] for [illegible]

[illegible] many [illegible]

habit[illegible] of [illegible]

Plate[illegible]

this zone [illegible]

the [illegible]

[illegible]

northern regio[illegible]

Mag[illegible]

[illegible]

with the other [illegible]

[illegible]

of the central mass, but observation establishes certain clear truths regarding the composition of the Ring. *It is by no means an uniform zone*, but rather a succession of bright spots, generally separated from each other by a comparatively dark line or space, manifesting *a succession of clusters* easily detected by the naked eye. These groups are for the most part of a spherical form, and are in many cases almost isolated. Nor is the peculiarity confined to the Northern Hemisphere. Plates XI. and XII. are eye sketches of part of this zone by Mr Dunlop, shewing its aspects in the southern hemisphere; which you will observe precisely correspond with my description of its northern regions. It is not improbable that the Magellanic clouds in the south, differ in nothing from these groups save that they stand alone; while the others form a successive bed or stratum through the Heavens. In both unquestionably there is *system*, and the ongoings of motion and change under control of that same law which stirs the double stars into action. "How much," says Sir John Herschel, in the enthusiastic confidence that even the immensity of such motions is not beyond reach of our faculties, "how much is escaping us! How unworthy is it in them who call themselves philosophers, to let these great phenomena of nature—these slow but majestic manifestations of the power and glory of God—glide by unnoticed, and drop out of memory beyond reach of recovery, because we will not take the pains to note them in their unobtrusive and furtive passage, because we see them in their every-day dress, and mark no sudden change, and conclude that all is dead, because we will not look for signs of life; and that all is uninteresting because we are not impressed and dazzled." "To say indeed," he adds, "that every individual star in the Milky Way, to the amount of eight or ten millions, is to have its place determined, and its motion watched, would be extravagant; but at least let samples be taken—at least let monographs of parts be made with powerful telescopes and refined instruments—that we may know what is going on in that abyss of stars, where at present imagination wanders without a guide!"

If the central mass be at all uniform, perhaps its whole suns will be united by one direct and primary sympathy; but it also may be made up of mighty subordinate groups. Proofs of motion among its stars, illustrative of the one or other phenomenon, are not now strange or unfrequent. I have mentioned in several parts of our discussions that great numbers of the stars enjoy proper motion—motions whose rates are fixed in many cases, and which affect bodies lying on all sides of the sun. Whether this be the activity of a subordinate group, or of the whole central mass, it is now clear that our sun partakes of it, and that he is sweeping along with his whole planets rapidly through space towards a point in the constellation Hercules. This important motion, first announced by Sir William Herschel, was afterwards thrown into discredit by the criticisms of some of our most acute modern astronomers; but we have the testimony of Struve that it is triumphantly re-established in a prize-dissertation by M. Argelander, which has not yet reached this country. The more we know of the heavens, the more are we constrained to wonder at the activity and acuteness of our illustrious Astronomer. Bold as he was and fond of generalizing, there is scarcely one single conjecture upheld by the authority of his name, which subsequent discovery has invalidated; and the most daring of all have been amply confirmed. Surely "the freshest stamp of Divinity was upon him!"—Of the periods of such motions as may sustain the groups I have now spoken of, not even imagination can form an idea; the periods of the grandest double stars will sink beside them into utter insignificance, and seem liker to the evanescent years of earth! But in this exquisitely related Universe, where the great and the small are interlaced and form one whole, even those boundless and immeasurable motions may not pass, without affecting, and assisting through their allotted destinies the small planets encircling our sun. The recent conjecture of a continental analyst is not to be summarily rejected or overlooked in a philosophical induction—that a degree of those changes of temperature which the earth has undergone since life appeared in it,—and because of which our northern climes were one day capable of harbouring the palms and gigantic ferns of the tropics—may have supervened in consequence of our gradual translation into chiller regions of space.

We approach the land of clouds and doubt —the solid ground of fact and observation is rapidly retiring from below us. Of the relations of these subordinate groups, or of the binding or compacting principle of our singular firmament, considering it as a *whole*,—I can inform you nothing. The more capricious class of external clusters equally mocks our imaginings; although the application of the principle of probabilities fully assures us, that these masses are not grouped together by chance or at random, but that through every such union of stars, law and system must prevail, as clearly as in binary or ternary aggregations. The only light we find among these spaces is a welcome gleam of evidence that Nature there also is uniform, since the simpler firmaments manifest by their shapes the prevalence of an *internal attractive power*—like that whose effective presence bestows consistency on our own subordinate clusters. Notwithstanding the apparent caprice of many of the firmaments, the *round* or *globular* structure is the general or favourite one, as you may judge from the representations in Plates I., V., VI.; and in most of these round clusters, there is also a *strongly marked increase of light towards the centre*, much more than would arise from the circumstance of our looking through the deepest part of the group, and thereby seeing at once the greatest number of its stars. This latter phenomenon decidedly indicates *compression* in greater or less degree, nor is it confined to masses having the perfectly spherical figure. "There are besides," says Sir William Herschel, "additional circumstances in the appearance of *extended* clusters and nebulæ, which very much favour the idea of a power lodged in the brightest part. Although the form of these be not globular, it is plainly to be seen, that there is a tendency towards sphericity, by the *swell* of the dimensions the nearer we draw towards the most luminous place, denoting as it were a *course* or *tide* of *stars*, setting towards a centre. And, if allegorical expressions may be allowed, it should seem as if the stars, thus flocking towards the seat of power, were stemmed by the crowd of those already assembled, and that, while some of them are successful in forcing their predecessors sideways, out of their places, others are themselves obliged to take up lateral situations, while all of them seem eagerly to strive for a place in the central swelling and generating spherical figure."

Arrived at this giddy height, we stop our train of thought—not unwillingly, for imagination is growing weak. The time may come, when we can pursue these contemplations with more stedfastness—when accurate Science shall have gone before us with her torch, and removed all cause of bewilderment. Anticipating such achievements, one almost participates in the elevation of the men who will realize them; and that mood leads us best to estimate the worth of those who have gone before, and conquered what we now enjoy. It is indeed attractive—to revert to the period when the forty-feet telescope first interrogated these profound heavens! The enthusiastic observer in the act of discovery, rises before the imagination, and the peace of midnight and the beauteous twinkling of stars; as also that other feature which characterised and farther elevated the scene. The Astronomer, during these engrossing nights, was constantly assisted in his labours by a devoted maiden Sister, who braved with him the inclemency of the weather—who heroically shared his privations that she might participate in his delights—whose pen, we are told, committed to paper his notes of observations as they issued from his lips; "she it was," says the best of authorities, "who having passed the nights near the telescope, took the rough manuscripts to her cottage at the dawn of day, and produced a fair copy of the night's work on the ensuing morning; she it was who planned the labour of each succeeding night, who reduced every observation, made every calculation, and kept every thing in systematic order;" she it was—MISS CAROLINE HERSCHEL—who helped our astronomer to gather an imperishable name. This venerable lady has in one respect been more fortunate than her brother, she has lived to reap the full harvest of their joint glory. Some years ago the gold medal of our Astronomical Society was transmitted her to her native Hanover, whither she removed after Sir William's death; and the same Learned Society has recently inscribed her name upon its roll: but she has been rewarded by yet more, by what she will value beyond all earthly pleasures; she has lived to see her favourite nephew, him who grew up under her eye unto an astronomer, gather around him the highest hopes of scientific Europe, and prove himself fully equal to tread in the footsteps of his Father.

PART III.

THE ORIGIN AND PROBABLE DESTINY OF THE PRESENT FORM OF THE MATERIAL CREATION.

LETTER VI.

THE NEBULÆ.

ALL that the telescope, aided by a bold and accurate science, has unfolded concerning the activity, forms, and condition of the Stellar Universe, is now before us. Pondering on its strange outline, we ask hesitatingly whether these arrangements are fixed—whether, what we behold, is the picture of all time—or whether visible phenomena have not a deeper significancy, and are results of a pre-existing state, or germinant of something future ? These questions warn me, that again we break new ground, and enter on speculations, perhaps the most adventurous which have yet engaged the reason of Man.

Astronomy has recently been obliged to recognise a Matter—or rather a modification of Matter, wholly distinct from stars—a thin and filmy substance diffused through the stellar intervals, and spreading over regions so immense, that its magnitude or the space it fills, is absolutely inconceivable. It unquestionably becomes us not to admit an element so remarkable, and which, if real, must perform important functions, and materially affect our general views of things—until its claims have undergone the severest scrutiny; and as I am desirous to convey to you full power of judging for yourself, I will here minutely follow the process of thought, by which Sir William Herschel—only, however, at a comparatively late period in the course of his researches—was, slowly and almost reluctantly, led to the conviction of its reality.

In his earlier inquiries, Herschel was inclined to consider all the faintly illuminated spots in the heavens, as clusters so remote, that only their general illumination, and no individual object could be seen; and the inference, so far from being constrained, seemed to result from his whole previous experience. On viewing the heavens, for instance, with a seven-feet reflector, while many distinct clusters were revealed to him wholly invisible by the naked eye, a great number of new illuminated spots were also visible. Now, on applying the ten-feet telescope, a proportion of these last were at once resolved into stars—others formerly of a milky hue put on the resolvable aspect; that is, they seemed like a distant handful of glittering dust; and although many retained their former irresolvable appearance, what more natural than to refer their continued intractability to their still greater distance? "When I pursued these researches," says our Astronomer, "I was in the situation of a natural philosopher, who follows the various species of animals and insects, from the height of their perfection down to the lowest ebb of life; when arriving at the vegetable kingdom, he can scarcely point out the precise boundary where the animal ceases and the plant begins, and may even go so far as to suspect them not to be essentially different. But recollecting himself, he compares for instance one of the human species with a tree, and all doubt upon the subject vanishes before him. In the same manner, we pass by gentle steps from a coarse cluster down through others more remote, and therefore of a finer texture, without any hesitation, till we find ourselves brought to an object such as the NEBULA in ORION, when we are still inclined to remain in our once adopted idea of stars exceedingly remote, and inconceivably crowded, as being the occasion of that remarkable occurrence. It seems, therefore, to require a more dissimilar object to bring us right again. A glance like that of the Naturalist who casts his eye from the perfect vegetable to the perfect animal, is wanting to remove the veil from the mind of Astronomers."

The object which broke in upon Herschel's previous continuity of inference was a *nebulous star*—a perfect star with a halo or dim atmosphere around it,—such an object as is represented in Fig. 1, Plate XX. I transcribe the record of the observation, and his subsequent remarks. After noting the elements which fix the star's place, he says, "A most singular phenomenon! A star of about the eighth magnitude with a faint luminous atmosphere of a circular form, and about 3′ in diameter. The star is perfectly in the centre, and the atmosphere so diluted, faint and equal throughout, that there can be no surmise of its consisting of stars." Herschel arrived at the latter positive conclusion as follows. "In the first place," says he, "if the nebulosity consists of stars appearing nebulous because of their distance, which causes them to run into each other, what must be the size of the central body which, at so enormous a distance, yet so far outshines all the rest? In the next place, if the central star be no bigger than common, how very small and compressed must be the other luminous points which send us only so faint a light? In the former case, the central body would far exceed what we call a star; and in the latter, the shining matter about the centre would be too small to come under that designation. Either, then, we have a central body which is not a star, or a star involved in a shining fluid of a nature wholly unknown to us." The latter alternative may, at first sight, appear the strangest and the most remote; yet it is the one to which the balance of probability manifestly inclines. And our judgment rests upon this,—the nebulous fluid, supposing it to exist, could not become known *under any other aspect or modification;* while, if stars of enormous comparative dimensions, were scattered through space, the likelihood is, that some one such body would be sufficiently near us *to permit of our recognising it under less ambiguous characters.*

Many other appearances—admitting of no plausible solution on the supposition that all those dim lights are sent from remote and accumulated stars—sustain the inferences just deduced, and thus greatly augment their probability. The wonderful Nebula in Orion, is in this respect a most instructive phenomenon. On directing the unaided eye to the middle part of the sword in that beautiful constellation, the spectator fancies on the first impulse that he sees a small star; but closer observation shows him that it is something indefinite—hazy—having none of the distinctness of the minute stars. When he looks at the spot through a small telescope, these suspicions are confirmed; and as the power of the telescope is increased, the more diffuse and strange the object. Its form, as revealed by a twenty-feet reflector, is shewn in Plate XIII.; but there is reason to believe that its low situation in our latitudes, conceals many remarkable

dimensions, were scattered [illegible] likelihood is, that some [illegible] sufficiently near us to [illegible] under the analogous [illegible]

[illegible]

strange [illegible] twenty feet [illegible] but there [illegible] tion is [illegible]

Pl. XIII.

radiating branches which are seen in the southern hemisphere. Now, observe two facts; — the Nebula is *visible to the naked eye*, and distinctly visible through glasses of small powers; and *the whole light and efficacy of the forty-feet telescope could not resolve it into distinct stars.* But, to be irresolvable by the largest telescope, the stars in the Nebula—supposing it a cluster—must be placed at a distance from us, which we cannot express in language; and to enable them to send us even a milky light through so vast an interval, they would require *a most improbable compression*, —improbable because unknown in degree even, in any explored portion of the universe. The hypothesis of a filmy or Nebulous fluid shining of itself, is thus again forced upon us, precisely as in the case of the Nebulous stars; and our general argument is here farther and very strikingly supported by the ascertained peculiarities of the mass. When telescopes are not sufficiently powerful to resolve a cluster, it still commonly takes on a succession of appearances, which distinctly indicate to the experienced observer—its resolvability, or stellar constitution. In the Nebula in Orion, however, no such change appears. It grows brighter in one sense, the larger the telescope, but only to become more mysterious. As we then see it, the illumination is extremely unequal and irregular. "I know not," says Sir John Herschel, "how to describe it better, than by comparing it to a curdling liquid, or a surface strewed over with flocks of wool, or to the breaking up of a mackerel sky, when the clouds of which it consists begin to assume a cirrhous appearance. It is not very unlike the mottling of the sun's disc, only—if I may so express myself—the grain is much coarser, and the intervals darker; and the flocculi instead of being generally round are drawn into little wisps. They present, however, no appearance of being composed of stars, and their aspect is altogether different from that of resolvable Nebulæ. In the latter we fancy by glimpses that we see stars, or that could we strain our sight a little more, we would see them. But the former suggests no idea of stars, but rather of something quite distinct from them."—This great Nebula seems to occupy in depth the vast interval between stars of the second or third, and others of the seventh or eighth magnitudes, and its superficial extent is probably corresponding. Its absolute size is thus utterly inconceivable; for the space filled by a Nebula of only 10′ in diameter, at the distance of a star of the eighth magnitude, would exceed the vast dimensions of our sun, at least 2,208,600,000,000,000,000 times!

Although to the interruption of our course of logical proof, I cannot refrain from adverting to some of the engrossing contemplations, which never fail to occupy me, when I gaze upon this remarkable substance. What is the intention of such a mass? Is it to abide for ever in that chaotic condition—void, formless, and diffuse in the midst of order and organization,—or is it the germ of more exalted Being—the rudiments of something only yet being arranged? Then too —although these questions were answered—what is its present state? It is not enough to tell us that for such and such ultimate purposes a certain object is destined,—we would know farther, the peculiarities and adaptations of its present or actual constitution? No part of creation exists merely as a *means*;—every thing is besides an *end* to itself: and within that looming mass, whatever be its final destiny, there are doubtless wide and systematic relationships,—each particle of its matter will be arranged and adjusted to its neighbour; nay, who can tell, who that has looked on those monuments of bygone worlds—the fossil relics which mark the early progress of our own planet—but, this amorphous substance may bear within it, laid up in its dark bosom—the germs, the producing powers of that LIFE, which in coming ages will bud and blossom, and effloresce, into manifold and growing forms, until it becomes fit harbourage and nourishment to every varying degree of intelligence, and every shade of moral sensibility and greatness!

Probable evidence of the foregoing nature might now be almost indefinitely accumulated. For instance, the magnificent appearance in the girdle of Andromeda affords similar conclusions. This Nebula, represented by Fig. 1, Plate XIV., is distinctly visible to the naked eye, seeming like a greasy spot upon the dark blue of the firmament, or a light shining through a horn; but as

sides [illegible]: and within that history, [illegible] final destiny, there [illegible] relationships,—[illegible] will be arranged and [illegible] may, [illegible] of these [illegible] which mark the [illegible] this [illegible] laid up [illegible] of [illegible] still [illegible] and [illegible] exchange and [illegible] of [illegible] and [illegible]

[illegible] foregoing [illegible] [illegible] The [illegible] is [illegible] to the [illegible] a [illegible] upon the dark [illegible] ment, or a [illegible] through a [illegible]

Pl. XIV.

with the Nebula in Orion, *no telescopic power has yet sufficed to give it the resolvable aspect*. Farther pursuit of such considerations, however, is unnecessary, inasmuch as we are in a condition to produce, what—taken in supplement—amounts to positive and direct proof at once of the reality and extensive diffusion of the Nebulous substance. I request your attention to the phenomenon of COMETS.—There is much connected with the comets of which we yet know nothing; but two general and essentially characteristic facts are established, and these suffice for my immediate purpose. In the first place, the phenomenon demonstrates not the *possibility* merely, but the actual *presence in Nature* of a nebulous modification of matter. The comets are nothing but *nebulosities*, small portions of a substance precisely similar in physical constitution to that which our hypothesis assumes. Even their nuclei dissolve into a fog under the inspection of the telescope. Fig. 2, Plate XIV. is a sketch by Sir John Herschel, of the second comet of 1825, and through the heart of another, the same observer once descried a cluster of stars of the sixteenth magnitude. Secondly: These small nebulosities are not connected with the structure of our solar system; from which we infer that *they are connected with some system in the spaces external to our limited sphere.* There is no essential tie between us and these comets; the variety of directions from which they come, altogether distinguishes them from the bodies which roll around the sun with singular and systematic regularity; they are chance visitants, most of them perhaps never approaching us but once, for, unless in a few instances, there is little reason to believe that their eccentric paths are continuous, or that they re-enter into themselves, and form a definite and bounded curve. But shall we therefore go into the usual inference, that the comets are mere anomalies—freaks of nature? Because they have no connexion with the order of our planetary worlds, is it necessary that they should have no meaning—no place in the universe? Look around you! What is there, what existing creature,—which has not such a place? Of the fine web of Being, fitness and relation are the warp and woof. Apparent anomalies are mere finger-posts, pointing where things lie of which we continue ignorant; and when such intimation is received with philosophic meekness, it invariably guides to unexpected discovery. These hazy bodies, now and then reaching our system, and leaving it without ever operating an appreciable effect, are not spectral and isolated monstra! As all things have a home in nature, they too doubtless hold relations with some grand external scheme of matter in a state of similar modification: and since, when influenced by the sun's attraction, they approach us from all quarters of the heavens, *the nebulosities in which they have their* ROOT, *must lie around us on* EVERY SIDE, *and be profusely scattered among the intervals of the stars.* What an error to fancy these Comets anomalies! They demonstrate *that*, which, as we have seen, is required to make a large and varied series of phenomena explicable. They are, in fact, absolutely indispensable; for without them the conjectural disclosures of the telescope would scarcely be established. And in accomplishing this service, they have also vindicated their own position; so that we have at once two of our best intimations that knowledge is advancing,—remote phenomena appear in closest relationship, and objects and occurrences formerly deemed insignificant, assume a place as constituents of the compact fabric of the Universe.

We touch on the most obscure problem of Astronomy. As every atom in existence has its object, this nebulous matter, found in such abundance, must have a prominence in purport answering to its prominence in magnitude. But when we ask, *What are the nebulæ?* we feel that we are venturing into that dim twilight which always surrounds the sphere of positive knowledge. If we would understand them, however, or know whether they are intelligible, we must examine if they can be arranged under characteristic peculiarities of *structure*, indicative of the operation of LAW; and it was the endeavour so to arrange them which led the Astronomer, whose torch has hitherto guided us, to conjectures promising, now more confidently than ever, to throw unwonted light upon the course of material transitions. I have, by means of diagrams, illustrated this part of our subject so fully, that I am encouraged to hope my reader will easily follow the arguments we are about to entertain.

In its first or rudest state, the Nebulous mat-

Pl. XV.

Pl.XVI.

ter is characterised by a *great diffusion*. The Nebula in Orion is an example of this, and Plate XV. represents a few other instances in which the milky light is spread over a large space so equably, that scarcely any *peculiarity* of constitution or arrangement can be perceived. The perfectly chaotic modification here illustrated, is perhaps the nearest to the original state of this matter, of any thing now remaining in the firmament; but the reason of its being found in separate patches, varying so much in form, manifestly appertains to remoter inquiries, and an inaccessible period in the History of Things.

Parting from these perfectly diffused and amorphous Nebulosities, *Structure* as governed by *Law* begins to appear. Even its first visible indications are very emphatic. The winding Nebulosity in Plate XVI. for instance, exhibits a congregating or condensing of the filmy matter in two distinct places, which look like bright nuclei, surrounded by a comparatively dark ring, precisely as if they had been formed by an actual *condensation* of the diffused matter, under control of the law of universal attraction. This is no anomalous appearance, for, in *every case*, the seeming commencements of structure are of the same kind. Nothing is any where met with, like a dispersion, or indication of a dispersive power; which probably would have been seen, had any power but an aggregating or condensing one been influential over the condition of nebulosities. This aggregating power, indeed, without the interference of any other, appears to lead to the entire breaking up of amorphous masses. The number of nuclei which are found in distinct nebulæ is variable; but there is never a departure from the character due to their supposed origination in a condensing principle. We have always a regular gradation in their intensities. The point of light grows brighter, while the vacancies or dark circles around the points are marked with more and more distinctness, until we reach a cluster of small round nebulæ perfectly detached from each other. The first figure in Plate XVII. represents an early stage of the phenomenon described; and the others in the same plate carry on the process of apparent separation in regard of two nuclei, until the masses are altogether distinct. The progress may be traced still farther. In their ultimate condition—that condition I mean in which

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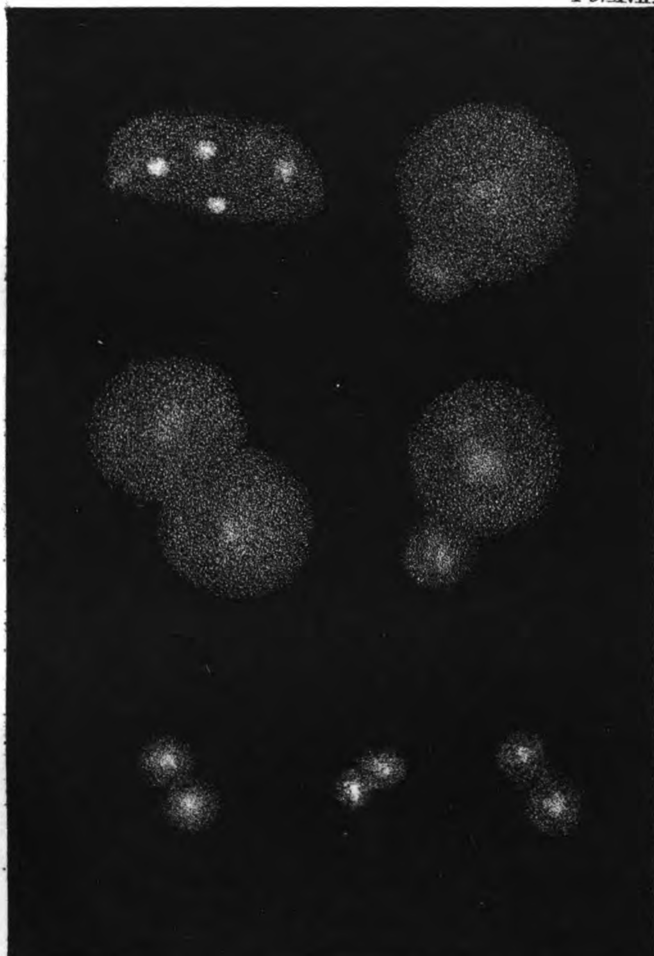
Pl. XVII.

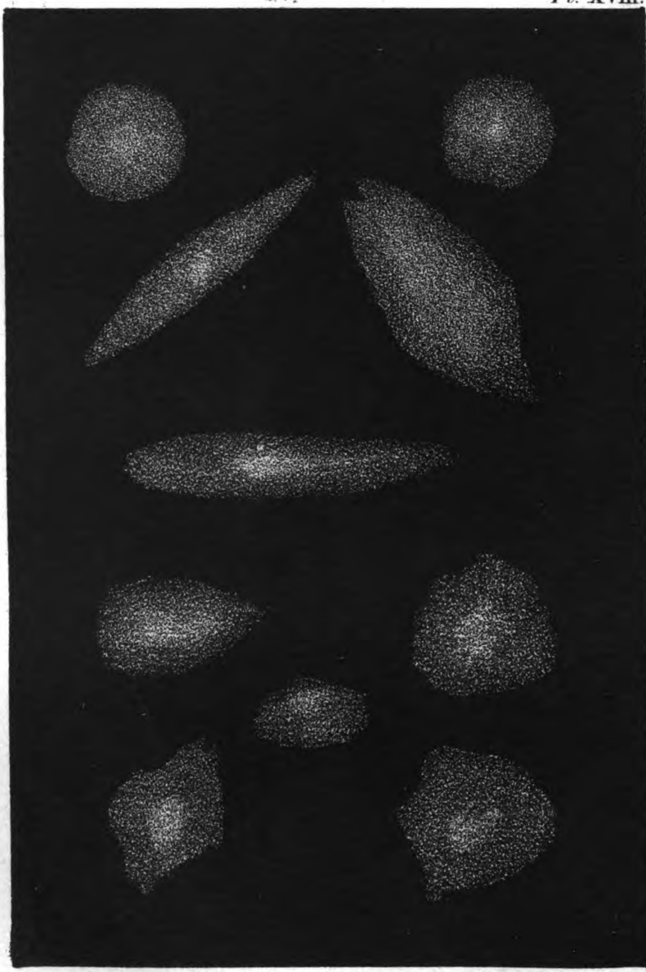


they seem to merge into stars—we find them distinguished from a double star or cluster, only in this, that they rest on a bed of very faint light. Of course when I speak of *progress*, I will be understood to signify the progress through a series of related contemporaneous objects in different and graduated states—not that progress which has never been observed—the passing, viz., of one nebula from an inferior into a higher condition. But is the conclusion rash, that this latter progress is possible? Is it not darkly but impressively intimated by the unbroken integrity of the series? What principle of philosophy hinders the supposition, that each of these varying bodies holds with those on both sides of it, also the relations of progenitor and descendant, that the unbroken contemporaneous series is also a picture, of youth ripening and manhood—in short, that the principle of attraction has actually brought such distinct round nebulæ as are seen clustering together, and also collections of stars imbedded near each other on a whitish light, from the bosom of masses like those looming elsewhere—still all indefinitely—among the recesses of our firmament?

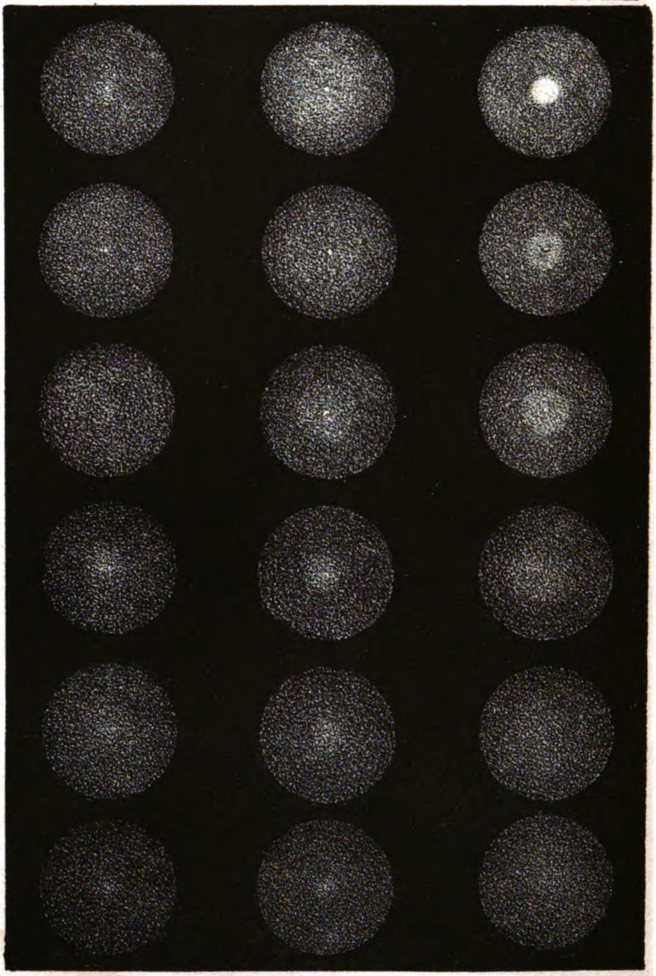
The hypothesis I have started is so strange, and brings up notions so unlike our common thoughts of the stellar universe, that it cannot and ought not to be received without an almost superfluity of evidence. We turn, accordingly, to single and definite Nebulæ, which are possessed of marked structure, in search of the light which they may throw upon it. And we get nothing here but confirmation. Their shapes, and the distribution of light in the separate bodies, so entirely accord with the hypothesis of condensation, that we have hardly room for evasion or escape.

Single Nebulæ characterised by structure vary considerably in form,—the usual varieties are shewn in Plate XVIII. Some are of an oblong shape, like that in Andromeda, with marked condensation towards the centre. We know not how these flat zones originated, but even in them structure when manifested always indicates condensation around the apparent centre of the mass. The great proportion of distinct nebulæ, however, are *round*, or nearly so. In Sir John Herschel's recent catalogue, the immense proportion are marked as round. Now we are bound to infer, that these round masses are *spheres*; for there

Pl. XVIII.

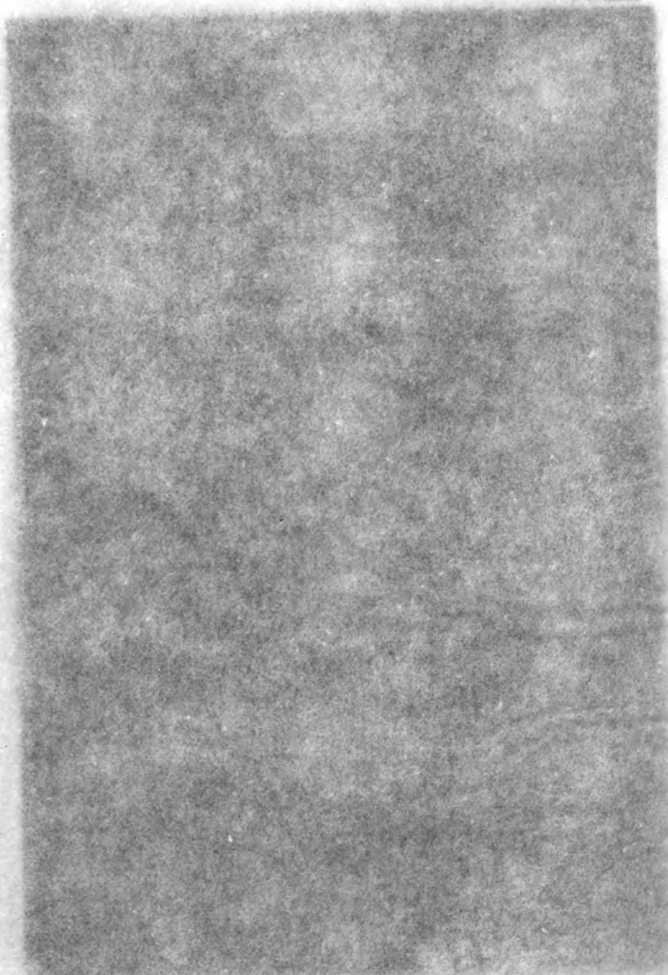


Pl. XIX



is no likelihood, that if they were cones or cylinders, they would all so lie in regard of our line of sight as invariably to present their circular sections. But the sphere is the shape *naturally assumed by masses whose particles mutually attract each other*; and on the principle that the globular shape of the rain-drop is accepted as a common illustration of the all-prevalence of gravity, and the sphericity of the planets held to confirm the same important law, this tendency in the nebulæ to the round form must be considered as a weighty and important argument. But it is the mode of the distribution of their LIGHT, which most confirms and settles these views. On the very first glance, this seems a phenomenon *connected with central influence*; for not only is the condensation uniformly greatest at the centre, but if in any nebula a circle of any radius be described around the centre, the illumination will be *found of the same intensity at every point of its circumference*. [illegible] the most remarkable and important fact [illegible] that wonderful *gradation* in the brightness of the central light. Plate XIX. speaks to the eye, and is more valuable than pages of [illegible].

Pl. XIX



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Each figure in that plate is the representative, not of an individual, but of an extensive class; and surely a series so well marked—so striking in its aspects—must indicate the presence and influence of a great law? From absolute vagueness, to distinct structure, and then on to the formation of a defined central nucleus, the nebula seems growing under our eye! The illustration of Laplace, reproduced by Mr Airy, here forcibly occurs to me: "We look among these objects as among the trees of a forest; their change in the duration of a glance is indiscoverable; yet we perceive that there are plants in all different stages; we see that these stages are probably related to each other in the order of time, and we are irresistibly led to the conclusion, that the vegetable world in the one case, and the sidereal world in the other, exhibit at one instant a succession of changes requiring time, which the life of man or the duration of a solar system may not be sufficient to trace out in individual instances." And the progression advances until it is complete. We have objects each more perfect than the last, like those Figures in Plate XX.; and in the end a STAR is

Pl. XX.

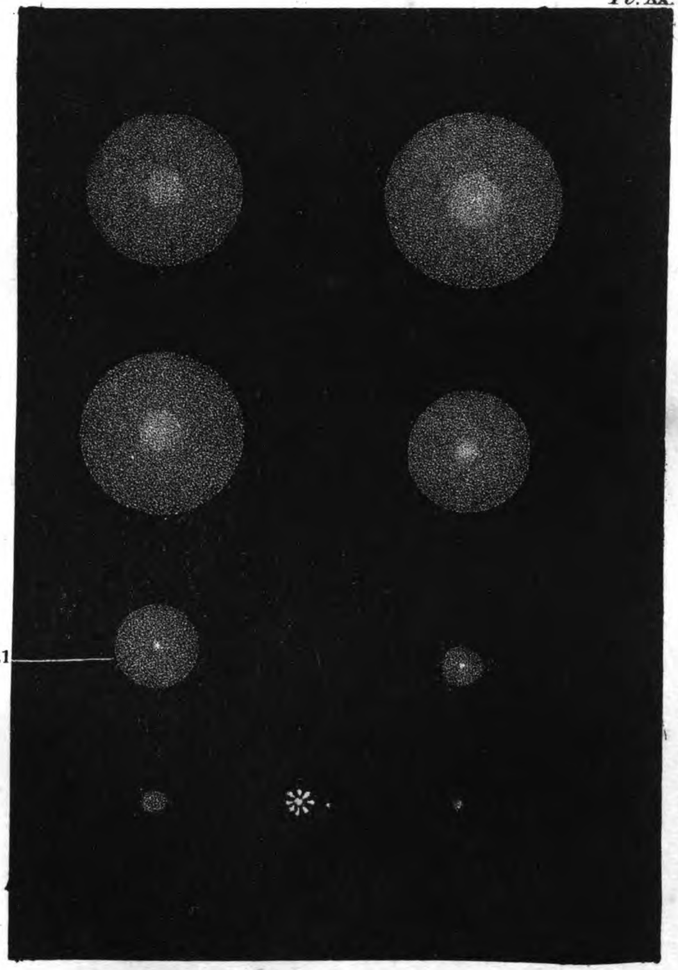

Fig. 1

found thoroughly organized with a mere *bur* around it!

Let us collect together and review for a moment the whole facts of this curious speculation. First, We discover a most striking series of objects partaking of the same nebulous constitution, and connected in an unbroken external chain or gradation, each object or link of which exhibits the nebulous chaos in a condition of greater regularity and higher consolidation than the preceding one; and the gradation only closes on reaching an organized star. Secondly, We are acquainted with an influence or process operating on every side of us,—an influence the most general in Nature, capable of effecting the conversion of a Nebula of one series into a more advanced one of the next; or to use more accurate language, the actual occurrence of such conversions would be far from unusual or strange, but rather in exact agreement with the course of that most extensive class of material events, whose laws we have hitherto recognised. It is a distinguishing mark of this hypothesis, that we institute no new power, or speculate on mere *possibilities*;

that Nature is uniform—that GRAVITY which controls the planetary, and, in so far as we know, all celestial spheres, acts also within these masses, is our boldest supposition. And, besides, there are *positive indications that it does act there.* The comets are under its influence, for they are attracted by our sun: their matter, therefore, is the same as planetary matter—obedient to gravity. Instances, too, are not wanting in which the original distribution of external nebulosities appears affected, or altered by the attraction of neighbouring stars. The upper and lower figures in Plate XXI. shew portions of it being drawn towards a star—as if feeding it—or stretched between two. The middle object in the same Plate is very instructive. It is a diffused nebulosity near a reticulated cluster of small stars, and its brightness follows their line; while in the spaces where no stars are, there is almost no nebulous matter, as if it had been nearly drawn away by attraction, and accumulated in those bright ridges, or absorbed.

I anticipate the objection of the difficult believer, "Shew us," he will say, "*shew* us a change, shew us the actual progression of one nebula from an inferior to a more organized condition. We

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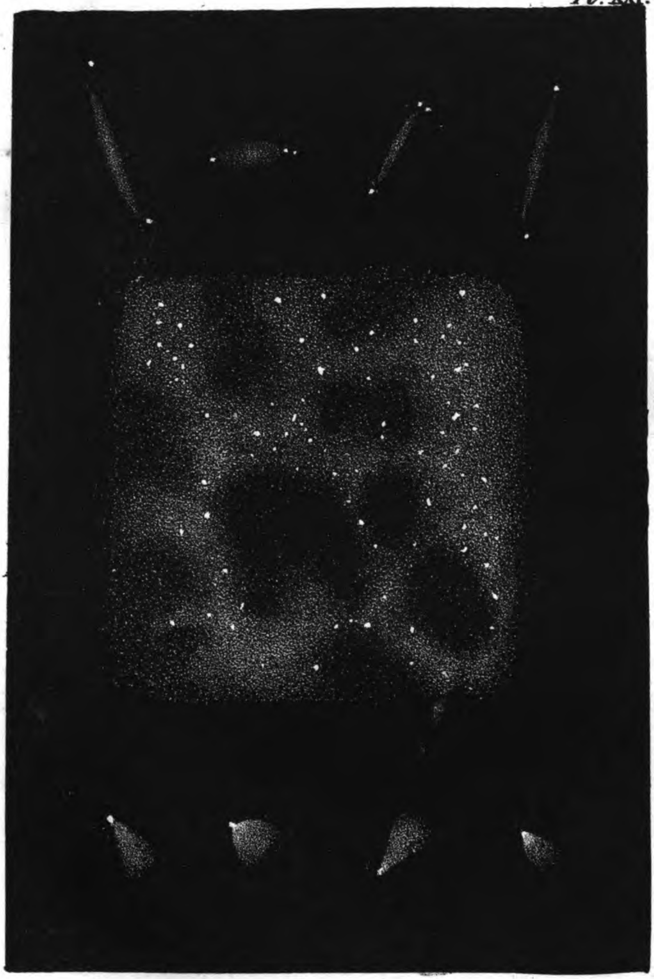
Pl. XXI.



grant the unbroken completeness of your series; we grant the law which could advance its individual constituents; but *actual change* alone is proof." Let no man, however, be deceived, or mistake the nature of the problem which is engaging us. The demand is infinitely more unreasonable, than if the inquirer into the motions of the double stars were to insist upon an actual inspection of the beginning and close of the vast year of Mizar and Alcor. If that nebular hypothesis be true, all the forces developed upon the thin surface of our planet, and which have given rise to geological transitions, stretching through periods in which the existence of the human race is an invisible speck, will have resulted during a stage of condensation in a secondary nebula, which no instrument from any fixed star could possibly detect. How, then, delude or disappoint ourselves by straining the eye after periods so enormous! There is a creature named the Ephemeron, whose life is confined to the veriest point of time,—in one short hour it dances out its existence in the sunbeam. That creature is in presence of all the phenomena of vegetable growth; it may see trees—it may see flowers, but how could it or its generations actually observe their progressive development? In relation to the nebulæ, Man is only an Ephemeron. Fifty lives succeeding each other, and of a length to which individuals often attain, would reach backwards beyond the recorded commencements of his race; and in the mutability of things, fifty more may constitute a line longer than his allotted epoch. And, no more than one hundred of those creatures, which are born, breathe, and die, could learn of the progress upwards of the majestic pine,—will Man ever learn of the changes of the Nebulæ!

The ideas I have now presented to you—august and strange though they are—should not appear in contradistinction to what every moment is passing around us. Supposing these phenomena did unfold the long growth of worlds, where is the intrinsic difference between that growth and the progress of the humblest leaf, from its seed to its intricate and most beautiful organization? The thought that one grand and single law of attraction operating upon diffused matter may have produced all those stars which gild the heavens, and, in fact, that the spangling material universe is, as we see it, nothing other than one phase of a mighty progress, is indeed duly surprising; but I appeal to you again in what essential it were different from the growth of the evanescent plant? There, too, rude matter puts on new forms, in outward shape most beauteous, and in mechanism most admirable: and there CANNOT be a more astonishing process or a mightier power even in the growth of a world! The thing which bewilders us is not any intrinsic difficulty or disparity, but a consideration springing from our own fleeting condition. We are not rendered incredulous by the *nature*, but overwhelmed by the *magnitude* of the works; our minds will not stretch out to embrace the periods of this stupendous change. But Time, as we conceive it, has nothing to do with the question—we are speaking of the operations and tracing the footsteps of One who is above all time—we are speaking of the energies of that Almighty Mind, with regard to whose infinite capacity a day is as a thousand years, and the lifetime of the entire Human Race but as the moment which dies with the tick of the clock that marks it—which is heard and passes.

LETTER VII.

THE NEBULAR HYPOTHESIS.

Let us note the exact amount of evidence constituted by the speculations of the foregoing letter, on behalf of the daring Hypothesis that all existing stellar bodies sprung by virtue of the law of attraction, from the bosom of a chaos of which stray specimens are still found in the Heavens. In so far as this Hypothesis undertakes to EXPLAIN THE NEBULÆ, I do not conceive that much of *accessible* knowledge is now wanting to confirm it; for, the agreement of the forms of the nebular substance with the natural results of the persevering action of gravity, seems almost demonstrated. But it must not be forgotten that there is another correlative and very extensive inquiry which this truth has not touched; *The Hypothesis must also* EXPLAIN

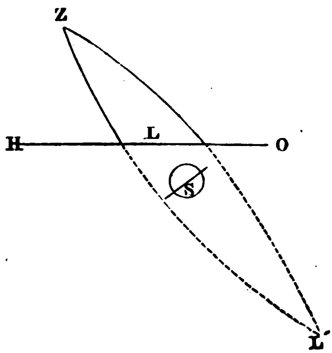
THE STARS. If it is the true Cosmogony, and we have at length approached a right theory of the Formation of Things, we should indeed obtain from it a satisfactory idea of the meaning of that curious progression of structure, which so strikingly characterises the Nebulous masses; but it is no less imperative that it exhibit with proper distinctness, how the mass of stars around us, along with their *peculiar features and arrangements*, might have been evolved in obedience to *known mechanical laws*, by the condensation of Nebulæ. To the inquiry thus suggested, I invite you rejoicingly; at every step in our pursuit of it, we shall gain new views of the unity of Things, indications of remote and unexpected relationships, and proofs the most illustrious afforded by Science, of the compactness of that Domain whose forms occupy SPACE, and the annals of whose changes constitute TIME.

I. There is no small difficulty in reconciling the imagination to the idea that an orb like our SUN—on which, as in our former survey, we naturally first cast our eyes—could have originated in a vague nebulous mass. Observation shews, however, that the *magnitude* of our luminary is no obstacle to the Hypothesis, for the statement in page 129 proves that a Nebula like that in Orion, contains matter or substance sufficient for the generation of a solid globe perhaps some millions of times as large. Neither can the difference between the *solidity* of the Sun and the *gaseous* condition of the Nebula, constitute ground for rational hesitation, inasmuch as in the laboratory of the chemist matter easily passes through all conditions, the solid, liquid, and gaseous, as if in a sort of phantasmagoria, and his highest discoveries even now, are pointing to the conclusion that the bodies which make up the solid portion of our Earth may, simply by the dissolution of existing combinations, be ultimately resolved into a permanently gaseous form.* But it should wholly reconcile you to this preliminary conception, if, partly by what seems the true interpretation of a phenomenon long noticed, and partly by aid of one of the most promising discoveries of modern times, I shew that the SUN is not yet pure,

* See Note C, at close of the volume.

that he *has not yet quite escaped the original nebulous character* I am attributing to him, and that, notwithstanding of his effulgence, he is still rather in the condition of a nebulous body—something like Fig. 1. Plate XX., where consolidation, although very far advanced, is not complete.

The first appearance referred to is the Zodiacal Light. This remarkable phenomenon consists in a long train of faint light of a conical form, left by the sun after setting, and projected on the sky. It is easily seen in tropical countries, but in ours it is visible only when in the most favourable position, and may be looked for on clear evenings in March or April. It has an appearance like that in the subjoined wood-cut,



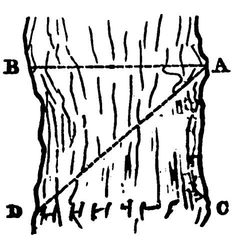
where S is the sun, HO the horizon, and ZL the faint light. Now, the axis on which the sun rotates is, as the Figure indicates, at *right angles to the greatest length or axis of the light;* from which simple fact, we venture to trace a connexion between that light and the axis or equator of the sun. Although we see only the upper part of it, that atmosphere is in all probability extended also on the sun's other side, as in the dotted part of the line; forming a regular and still uncondensed relic of some *oblong nebula*, in which our luminary probably originated. Of this at least we are certain—the Zodiacal Light is a phenomenon precisely similar in kind to the nebulous atmospheres of the distant stars; and, *these atmospheres have already been connected by a long and unbroken progression with their parent amorphous masses.* In relation to its extent, indeed, it is utterly trifling when compared with the smallest of the stellar nebulæ; for its diameter is less by millions of times than the average of these curious bodies, and if we looked from the nearest of the fixed stars we could not recognise it or guess its existence with the aid of Herschel's largest telescope: but this fact, so far from being barren or forbidding, is itself a ground of important and cheering inference. Previous even to the discovery of such a circumstance, no one could have asserted confidently that the nebulous atmospheres of the stars terminated actually at the point of magnitude below which we cannot see them, or at the varying limits of their visibility to us: but we are now furnished with substantive reason to believe that the phenomenon of the illuminated bur *does* extend much farther; that vast numbers, if not the whole, of the bright and apparently pure constituents of our firmament, may still have Zodiacal Lights; and that the nebulous phenomenon, although to our imperfect vision now characterising but comparatively few objects, may, notwithstanding of the long lapse of hither time, continue to possess a generality of which all that we see is only the faintest indication.

The other and new phenomenon—one no less remarkable in the mode of its discovery, than because of its intrinsic value—is equally confirmatory of the nebulous attributes of the sun. The nebulous stars, as seen by our telescopes, have very commonly a well marked increase of light towards the centre; or, what is the same thing, a gradual diminution, or shading off, towards their edges. Now, this Zodiacal Light is probably only the *brighter part* of the solar nebulosity, which may extend much farther. In this further extension it may not give out sufficient light to be perceptible; and the fact is, if it includes the Earth, we could not see it, although it emitted a very considerable quantity of light. Being in the midst of it, its light could evidently not be observed as an *external* thing: it would be confounded with that faint illumination arising from the intermingling of the rays of all the stars, which somewhat brightens the dark ground of our skies; and must have remained unknown, but for another mode of experiment. In note A, at the close of the volume, where the planetary phenomena are rapidly surveyed, I have shewn how the permanence of the orbit of each planet depends upon the perfect balance of two forces or tendencies, viz., the attractive power of the sun, and that tendency to fly from the centre, which follows from the motion of bodies being naturally in straight lines, and whose energy depends, in each case, upon the rapidity of the body's motion. If the power of either of those balanced forces be diminished, it is clear that the authority of the other will prevail. Relax Gravity, therefore, and the planet will recede from the sun, and its orbit widen until a balance is restored. In the same manner, diminish the rapidity of the body's motion, and, as the centrifugal force will be diminished by the same act, Gravity will prevail;—so that the body's orbit will be *contracted* or *drawn in*. Now, if a nebulous fluid is diffused through the planetary spaces, every body which moves through it must experience resistance and be *retarded* as we are by the atmosphere, when riding at a rapid pace; and we would thus expect to trace the ether's existence in the fact of the planetary orbits gradually drawing in, and the revolving bodies approaching the sun. Unhappily, however, for this only mode of observation left, the planets are too dense, too large to be of service in so delicate an inquiry. However light and thin the ether, there is no doubt that it must and will influence even *their* motions; but perhaps, by a quantity so small, that the accumulation of the perturbations arising from it during the whole period of accurate astronomy, would not render it perceptible. No trace of such influence, indeed, is yet found in our planetary tables; and astronomers would have been left in regard of the whole subject to conjectures, which, however plausible, had yet no actual or experimental *ground*, unless for a remarkable and certainly an unlooked-for occurrence. Until recently, astronomical science has not been able to present a complete and minutely accurate view of the orbit of any comet. The general character of the orbits of these bodies, and the important elements, at least of *one* of them, have been known since the time of the celebrated Halley; but this philosopher knew nothing further than the general elements; and no orbit was laid down with exactness sufficient for the above purpose, until Encke of Berlin examined with so much accuracy the conditions of a *body*—if a thing so small and vaporous merits the appellation—which completes its eccentric course around the sun in 3½ years. Now, it appears by observation, that this comet *is approaching the sun;*—on every successive appearance, we find its orbit somewhat contracted, and there is reason to believe that the contraction will go on until it is either absorbed in that luminary, or altogether dissipated by his beams. And after vainly searching for some other cause, inquirers are nearly unanimous in referring this extraordinary and hitherto unparalleled change, to a RESISTING MEDIUM OR ETHER occupying the planetary spaces. "I cannot but express my belief," says Professor Airy, "that the principal part of the theory, viz., an effect exactly similar to that which a resisting medium would produce, is perfectly established by the reasoning in Encke's memoir;" and similar opinions have been offered by other great authorities. That the sun, then, has a widely diffused nebulous atmosphere—extending far beyond the limits of the Zodiacal Light, and if not beyond, at least deep into the planetary spaces—an atmosphere of which that light may merely be the densest portion is at length rested on a high degree of probability: and how singular is it that we should have been guided to a truth so remote and difficult—one concerning which the grander phenomena of our system are silent, by the motions of a wandering object, in comparison with whose ethereal nature, even one of these light flocculi or flakes of cloud, which scarce stain the sky of a summer evening, is heavy and substantial! Even thus harmonious is the universe! And seeing the perfect continuity of that golden line of order, which unites its mightiest phenomena with its least, so that the motions of a speck of dust may illustrate causes adequate to generate worlds,—what achievement is too high to be hoped for future discovery, and why may not a time arrive, when, in return for man's close observation, and unwearied questioning of nature, the darkest of those speculations in which we have just been indulging, shall be doubtful and venturous no more?

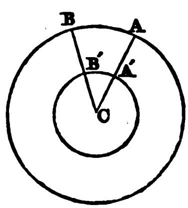
If consideration of these circumstances has sufficed to destroy your natural repugnance to the resolution of our effulgent sun into a Nebula, you will be prepared to start the next question—the question as to the capacity of the Hypothesis, that the sun sprung from such a mass, to explain the most remarkable feature of his Being, viz. his rotation round an axis.

When we reflect on the Solar or any other nebula in the act of condensing, it appears that the phenomenon consists in a flow or rush of the nebulous matter from all sides towards a central region; which is virtually equivalent, in a mechanical point of view, to what we witness so frequently, both on a small and large scale—the meeting and intermingling of opposite gentle currents of water. Now what do we find on occasion of such a meeting? Herschel's keen glance lighted at once on this simple phenomenon, and drew from it the secret of one of the most fertile processes of Nature! In almost no case do streams meet and intermingle, without occasioning where they intermingle, a *dimple* or WHIRLPOOL; and, in fact, it is barely possible that such a flow of matter from opposite sides could be so nicely balanced in any case, that the opposite momenta or floods would neutralize each other, and produce a condition of *central rest*. In this circumstance then—in the whirlpool to be expected where the Nebulous floods meet—is the obscure and simple germ of rotatory movement. The very act of the condensation of the gaseous matter as it flows towards a central district, almost necessitates the commencement of a process, which, though slow and vague at first, has, it will be found, the inherent power of reaching a perfect and definite condition, and from which consequences ultimately issue, not less various and astonishing than the foliage and stature of the noble tree, considered as the development of an insignificant seed.

You will have no difficulty in perceiving, that —the whirlpool motion once originated—there is an inherent power in matter, under such circumstances, to evolve finally a definite rotation of considerable velocity. It is a general law or fact, that if a body is subjected to two moving influences acting in different directions, *it obeys both*, or moves in obedience to each, as if the other did not exist. For instance, let a person in a boat start from A, with the intention of push-



ing his boat right across a stream; and suppose, that in the time he would occupy in rowing from A to B, *if the water were still*, the power of the stream could carry him from A to C *if he did not row at all;*—the question is, how his boat will actually move? Now, all experience tell us, that if he merely rows *right across*—pushing his boat from the bank A towards B, with its side invariably to the stream, he will, previous to reaching the opposite bank, have been carried down by the current, precisely as far as if his boat had merely floated; so that he will reach the bank at D, immediately opposite C, and his boat will have *partaken at once of the two motions or influences impressed upon it.* This law, as I have said, is general; it holds in every case where a body is under the influence of two moving powers; and the consequences of its action in a condensing nebula, cannot be mistaken. Let the subjoined sketch represent



a section of a circular nebula, revolving about the central region C, and in which condensation is permanently going on. It is evident that the particle at A, in consequence of the whirlpool, moves from A to B, while the particle at A′, only moves from A′ to B′; but, as the attractive power, by drawing the first particle from A to A′, cannot, by the foregoing principle, *diminish its circular velocity*, the result of such condensation will be *the attaching to* A′ of another particle A, whose circular velocity is greater than its own. Now, the permanent consequence is manifest. If two balls, A and B for instance, are moving forward with different velocities, A much faster than B, what

will follow when A overtakes B? Certainly an acceleration of B's motion, and a retardation of A's; and the two together will, after contact, move on *much more rapidly than at B's former rate:* so that, by the very act of A (see Fig. on previous page) being brought into union with A′, the rotatory velocity of A′ would be augmented; and if the whole *outer* circle A B, &c., were attracted towards the inner circle of matter A′ B′, &c., that inner circle would accordingly rotate more rapidly than before, and the velocity of the rotation of the entire nebula must therefore be increased. Physical objections, I am aware, may be taken to this explanation;—I propose it merely as a *popular* one: but it indicates, nevertheless, the principle which assures us that the condensation of a diffused and comparatively slow whirlpool cannot take place without a great and growing increase in the velocity of its rotation, inasmuch as the momentum or amount of the *rotatory force*, must, in all its stages and conditions, continue the same. And thus, if you have followed me, you see how out of phenomena the rudest and most unpromising, and by the simplest laws of nature—those which guide the facts of every-day experience,—even that stupendous rotation might be generated—a rotation whose discovery was one of the first achievements of the telescope, and which, all who know Nature ought to be assured, does not stand by itself or as an independent fact, but is a cosmical phenomenon of wide significancy, and closely however mysteriously related with the whole scheme and progress of Things.*

II. Our conclusions are already of great importance, and will lead us far. Not only are we now able to look upon these myriads of single suns, as having come—as probably at least as our own luminary—from the womb of the Nebulæ; but we have likewise generalized the phenomenon of rotation by generalizing its cause, inasmuch as the foregoing demonstration applies to any condensing mass: and from the vantage ground of this farther and almost unexpected insight into phenomena, we can proceed with some confidence to take cognizance of the general fact next in order of simplicity,—viz. that evolved by Herschel's fine induction from the existing statistics of the Heavens—the law of the *revolving motions of stars associated in limited*

* The velocity of the resulting rotation will manifestly depend on the magnitude and condition of the original Nebula; so that we would expect to find no uniformity of period in the rotations of the stars—an expectation perhaps verified in the phenomena of the *variable* orbs. The probable variations of size in the original Nebulæ, also leads us to the supposition that there is probably a very great variety in the magnitude of the resulting stars.

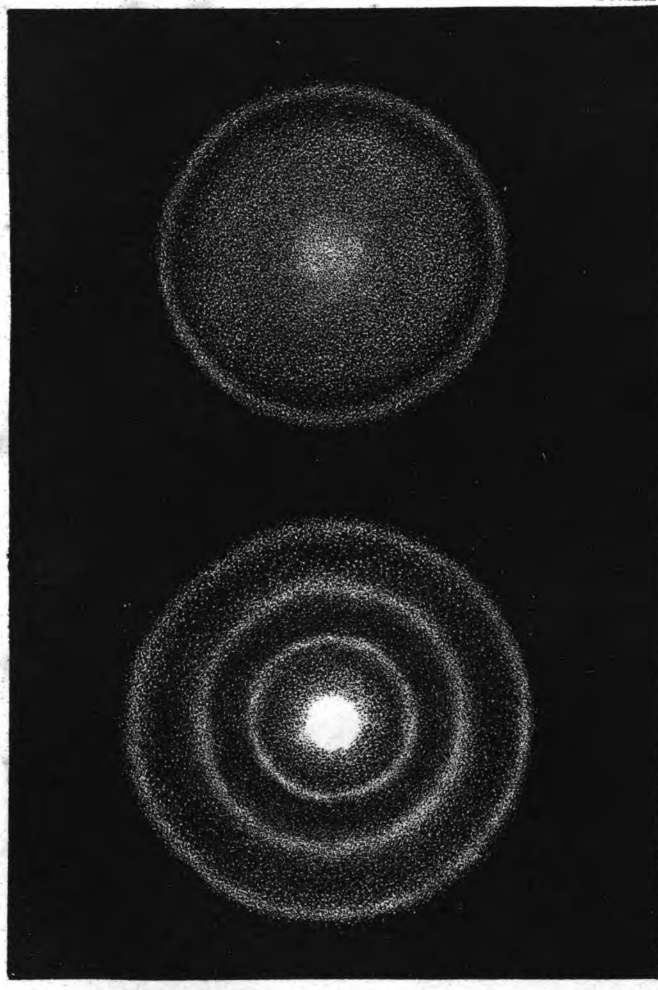
and compressed clusters. The solution of this great and interesting law afforded by our Hypothesis, I cannot term less than picturesque,—it excites instantaneously our surprise and admiration. Have you ever walked in a mood of tranquil thought along the side of a quiet river, whose waving banks reflect a thousand currents, by the intermingling of which, numerous dimples or whirlpools are produced—their easy glide only marking the river's stillness? Have you seen these dimples follow and pursue each other as if in gambol, or watched the phenomenon of the near approach of two or three? Then have you witnessed the secret of the mystery of the double and triple stars! When one of these dimples reaches the verge of another, the two begin *to revolve around each other;* and in fact they must, on approximation, act upon each other as *two wheels*, so that a revolution of each around the other *must* immediately supervene, and increase in rapidity, until, by external pressure, they are forced into one. Plate XVII., in which Double Nebulæ are presented in various stages, enables us to apply this illustration. If the single nuclei are rotating, as we are now almost entitled to say they must be, it is precisely a case of two contiguous whirlpools; and *how could revolutionary motion be prevented?* Two such masses in approximate contact *must* originate such a motion: as the principle of gravity draws the nuclei nearer each other, the velocity of revolution will manifestly increase; and the two bodies will constitute themselves into a stable system when the rapidity of revolution suffices to counterbalance their mutual attraction. The case is manifestly the same in instances of three, four, or more nuclei, formed in the immediate neighbourhood of each other, or out of one such mass as Fig 1. in the same plate: so that now we have not only a CAUSAL solution of Herschel's remarkable prophecy; but also an intimation that the *modes* of revolution of small clusters, may be as varied and fantastic as the multifarious revolutions of associated dimples in a stream. To deduce from the dynamical laws which govern the interlaced motions of these tiny whirlpools, the *classes* of related orbits whose discovery may be expected in the sky, were in the mean time premature;—the more so that our conjectures concerning this peculiarity in the play of the Nebular hypothesis, present a point of experimental but unexplored verification. *All known double Nebulæ should be sedulously watched ;* although they may move slowly, still their motions might in some instances be detected;—a positive discovery which I do not hesitate to allege would not be second in interest to that which has immortalized our age—the discovery of the actual motions of the double stars! . . . I am not sure that the portion of the nebular speculation over which I have just gone, is not in my eyes the most engrossing of the whole of it, for it points emphatically to a moral I am extremely anxious to impress. We are all too easily inclined to look on creation as made up of isolated parts—of independent or individual classes of beings, and to regard Nature as we do a case of botanical or mineralogical boxes ; so that it requires a fact as striking as the identification of the Stellar motions of REVOLUTION with those of ROTATION, to startle us from the habitual error, and to bring us to right views of that stupendous ORDER within which we live, and of which our own beings constitute a part. The unity of things—their interdependence — their adjusted relationships, are proclaimed by every department of the Universe. I deny not that different laws may exist; nay, they *must*,—for it is only by the commingling of Opposites that Variety and Progress can be produced; but all is not opposition which seems so, and most of what we divide and parcel out into isolated bundles, is nothing other than the parts of the same grand scheme. Philosophy has taught this for ages—it is, in fact, the secret of her life; for she aims to gather up all fragments, and to present the Universe united, compact, tending to one end—a type of its August CREATOR.

III. We are not yet done with tracing the wide and wonderful consequences of the Rotation of Solar Orbs. Singular though it appear, the next attribute of the Sun—the fact of his being surrounded by PLANETS, springs necessarily out of his Rotation; from which we likewise deduce the whole forms and mechanism of the system which belongs to him. If the discussions I shall present to you are somewhat more difficult and tedious than the preceding, I believe they will yet reward your attention, for we are also about to demonstrate that law, at which on several occasions I have hinted—the necessary existence of planets around every star in which the elementary principles of matter, as we know it, are freely operative.

1. The preservation and permanence of the place of a point on the surface of a rotating body depends, as I have said, on the circumstance that the centrifugal force is not greater than the power of the central attraction. The inevitable consequence of an excess of the former is seen in simple operation in a common phenomenon. It is known to Mechanics, that a grindstone may be made to revolve with a rapidity sufficient to cause splinters fly from its rim, and even the whole rim to break in pieces—indicating that the centrifugal force of the rim with that velocity, more than counterbalances the mutual attraction or cohesion of the particles of the stone. Now, if the rim, instead of being formed of brittle stone, had consisted of an elastic belt, say of caoutchouc, what would result in such a case? Clearly a separation of the rim from the mass of the rotating body — it would expand somewhat, just as the orbit of a planet in

a similar position; and if other circumstances permitted, it would revolve around the stone as a separate ring at a distance where the balance or equilibrium of the forces would be restored. Plate XXII. will enable us to apply these considerations to the case of a condensing and therefore *rotating* Nebula with striking effect. Fix your attention on Fig. 1. We have already seen that causes continually operate to increase the velocity of the Nebula's rotation; but when this velocity in any case became so great that the centrifugal power of the exterior portion or ring just balanced the attraction exercised over it by the mass of the Nebula, that ring would necessarily assume an independent character, and acquire, so to speak, a self-subsustaining power; it would therefore be *abandoned* by the main or parent mass at the next stage of condensation, and left as a *distinct portion of matter revolving in* SOME FORM *around the central body*. There is no doubt whatever of the mechanical principles on which these inferences rest; and it is equally certain that there are almost infinite chances against the condensation of any large or original Nebula, without the occurrence

Pl. XXII.



of circumstances which would throw off numbers of such rings; so that, in a more advanced condition, every such mass might (*if the forms of the thrown off rings had not altered*) present the appearance of the second figure in Plate XXII.,—a large central nucleus, with subservient rotating annuli, composed of quantities of matter necessarily very small when compared with the main body.

Here, then, have we our first idea of the origination of planetary—or of quantities of parasitic revolving matter; and the question next arises, what *forms* would these rings probably ultimately assume? There are three possible forms. 1. The mass, if tolerably equable in its original constitution, and undisturbed from without, might condense as it is, or into a *rotating* SOLID RING; but the chances against such a result are so numerous, that we would expect the phenomenon to be very rare in the Universe. 2. If the mass broke up or separated while condensing—as its own internal irregularities would in all probability constrain it to do—it might divide into a number of portions so equal in attractive energy that none of them would have any tendency to coalesce with, or fall into the others; so that the ring would ultimately be transformed into a number of distinct small solid bodies, revolving around the central mass at nearly the same distance from it. These bodies, it is clear, would in their final state be *spherical* or *round planets;* and although not so evident, it is yet mechanically certain, that they would *necessarily rotate on their axes in the direction of their revolutions.* 3. Even this second supposition, however, is not a very probable one, inasmuch as its essential condition—the attraction of the mass of the ring towards equally balanced centres—could in the nature of things occur but rarely. By far the likeliest result is the division of the ring into nuclei of unequal power—the larger of which would, by its superior attraction, assume the others into its mass,—the whole solidifying into one considerable globe. Such globes would likewise invariably follow the law of rotation above specified; and every one of these secondary masses, might, during the phenomena of its subsequent condensation and augmenting velocity of rotation, throw off rings corresponding in all respects to those around the primary nucleus,—

which condensing in their turn, and according to the foregoing laws, would form solid annuli and *Satellites*.

How exact is the correspondence of these general results with the character of the bodies in our solar system! 1. We have a central massive globe, with subservient globes engirdling him at various distances, and of magnitudes very inferior to his. 2. The great proportion of the planets which compose our luminary's cortege, belongs in strict accordance with theory, to the last of the three defined classes of forms into which a ring might break up. MERCURY, VENUS, the EARTH, MARS, JUPITER, SATURN, URANUS, are single globes, revolving in orbits of their own, and around some of them are dependent satellites. 3. In one instance only, does the ring seem to have divided into equally balanced parts—I allude to the four small planets, those ASTEROIDS between Mars and Jupiter, which have nearly a common orbit, or which revolve at almost the same distance from the sun: and 4. We have, also in one solitary instance, a specimen of that most singular of cosmical appearances—AN ORI-

GINAL RING, solidified in its pristine condition, and revolving around the planet SATURN.*

2. But although it thus accounts for the origin of our system of individual bodies, the hypothesis must be tested by a still severer criticism, and reconciled with the mechanism of the entire system.

First: It must yield a law accounting for the relation of the velocity of each planet to its distance; it must shew that the velocities, or times of the revolution of the several planets, are consistent with the account given of their origin. Now the inquiry which contains the reply to this query is not difficult, and has lately been taken up and completed by a young

* It is not unlikely that there are many other very small bodies which have come into being in the same manner as the others, revolving in various and *disturbed* orbits, within our planetary spaces. Meteors, or falling stars, are now generally believed to be most easily accounted for, by supposing them bodies of this sort drawn within the earth's atmosphere by attraction, and there ignited. The annual occurrence of a shower of meteors in the month of November, distinctly intimates the existence of an unexplained *astronomical* phenomenon; because, by being connected with the ecliptic and a particular season of the year, it is connected with the position of the earth in its orbit.

French geometer. The velocities of the several planets should clearly coincide with the period occupied by the sun in rotating on his axis *at the time when his atmosphere extended to their present orbits.* Now the times necessarily occupied by the sun in rotating in these earlier states, are *calculable;* and we find the most singular coincidence of theory with observation. Each planet revolves at present nearly in the time in which he must have rotated when the corresponding outer zone of his atmosphere was abandoned—a circumstance which M. Comte considers as bestowing almost demonstrative evidence on the Nebular cosmogony. I have said *nearly*, for the coincidence is not complete; the calculated time of the ring being shorter than the true time of the planet by about 1–45th part of the latter; but this difference, so far from overthrowing the presumption arising from the close correspondence, only opens more engrossing questions. The difference between the two periods must have originated in some laws and definite actions, although they are yet unknown; and will bear some proportion *to the time which has elapsed since each planet was first abandoned.*

Future analysis will unquestionably detect these laws; from which, the deduction of the epoch of the actual origin of the parent ring of any planetary body would not be arduous, and we should thus be able to construct an actual chronology of the formations in our System!

Secondly, There is a signal peculiarity and co-ordination in the arrangements of the motions of our planetary bodies, whose origin must be unfolded.

The planets, without exception, move around the sun in ovals differing little from circles, and never far removed from the plane passing through the sun's equator; they all revolve in these orbits in the direction of the sun's rotation on his axis; they rotate on their axes in the same direction, and—excepting what we have been told concerning the still enigmatical and but partially known body, Uranus—the whole Satellites, including the rings of Saturn, revolve around the primary planets also in that direction; nor are the rotations of these secondary bodies, in so far as they are known, subject to a different law. Now, these phenomena receive no explanation from what we usually term the law of gravitation, inasmuch as gravitation could sustain systems distinguished by no such conditions,—nay, it actually does so, for the comets are free from all these laws, they move in very eccentric orbits, often very far removed from the plane of the sun's equator, and their motions are as often retrograde as direct. Most fortunate it was that an inquiry baffling even the resolving power of Gravity, and thus profounder than any undertaken heretofore, fell into the hands of a philosopher whose knowledge of celestial mechanism was then complete, and whose capacity to trace elementary laws to their remotest consequence, has never been surpassed! It occurred at once to the illustrious LAPLACE, that the ordinary operation of Gravity is to sustain or regulate systems which have been brought into being; and that the higher conditions of which I have spoken, pertain directly to the manner of our system's origin; nor did he meditate long ere the splendid speculation I have detailed arose in full maturity in his mind, and connected itself with the revelations men were at that time first receiving from the telescopes of Herschel. Observe how intimately the system of the generation from *rings*, co-ordinates with these constituent phenomena. The rings in the first instance must be circular, and thrown off at the sun's equator where the velocity of rotation and therefore the centrifugal force is the greatest; the bodies resulting from them must revolve all in one direction, and with velocities corresponding to the velocity of the Nebula at the period of their separation; the separate and consolidated masses resulting from their destruction must, as stated, rotate on axes in the direction of their revolution; and finally, all Satellites subsequently formed must both revolve and rotate according to the same order! The Cosmogony has thus every mark of truth: its roots are *seen* in the Heavens, and it appears to go through every nook and alley of solar and planetary arrangements, not only explaining them, but comprehending their variety, and deducing the whole from one grand principle. How different the Cosmogony of Buffon—a man to whom genius was never wanting, who brightened every subject on which he touched, and kindled every mind which approached him, because, although with faculties imperfectly balanced, he lived and had his being amid the richest and rarest qualities of the philosophic spirit,—how different and wholly fantastic his idea that planets were chips struck off the sun by the collision of comets! Not one of the fundamental conditions of our system's mechanism could be explained by this wild and reckless imagination, whereas Laplace's bold and brilliant *induction* (may I not now so name it?) includes and resolves all! The theory is so beautiful and perfect, that perhaps we might have assumed it to be universal, and asserted that every planet springing out of rotation, and engirdling each of those infinite orbs must be subjected to the chief laws which control the earth—had not presumption been checked by one emphatic indication. If, as we are informed, the two least problematical Satellites of Uranus have retrograde motions,* *i. e.* if they move in directions opposite to the general one, there must be some influence or law capable of checking in so far and modifying the operations indicated by

* These are the only two satellites of this remote body which has been seen since the time of Sir William Herschel. It is scarce to be doubted that their motions are retrograde, and in orbits highly inclined to the ecliptic.

the Nebular Cosmogony; and this intimation reaches us from the farthest verge of our system —that confine where novel external actions would be the most sensibly felt. Whatever this influence is, it cannot invalidate the theory of Laplace. The laws of nature never destroy but only modify each other,—just as the systems of circular waves diffused from two centres in a pool, intermingle and affect each other's undulations—each spreading meanwhile out to the extreme limits of the sphere.

We have been advancing very rapidly—let us pause now and look back on the grand perspective below us. We set out by asking, can the Nebular Hypothesis *explain the stars?* Somewhat indeed remains to be fathomed, and phenomena apparently disparate may still be found in the sky; yet, short way as we have gone, every one of the grand features of the stars—facts, which but to mark, have often worthily conferred deathless fame—are seen in union and harmony the most unexpected, proceeding hand in hand from the bosom of previous night, and going through untold ages in singular companionship,—

as if we had even attained the privilege of witnessing the arranging influence of that Dove Spirit which erst brooded over chaos. It is indeed an impressive spectacle! Who can ascend so far up that vast chain which unites the eternal past with the fleeting present; who—to go no higher—can dwell on the idea of our Sun being born from one of those dim nebulæ, order growing within him by effect of law, and the worlds he illumines and sustains, springing gradually into being,—without engrossing emotions! Sometimes on contemplating this mighty progression, and thinking of the changes, visible and concealed, which must have marked the advance of an organization so majestic; asking, too, what is Man, save a transient organization, with whose progress the education of a Spiritual Being has been for a moment connected—I confess I have been so fanciful as to doubt whether those great and good men who endowed the stars with spiritual principles, ought to be deemed mistaken,—whether that orb, during its fathomless evolutions, may not have been the seat of a SPIRITUAL POTENTATE, gifted with the glorious capacity to rise in knowledge, power, and beneficence, by experience of all the vast events of which he is the centre—whether we should not look upon these HOSTS of HEAVEN, as something still more awful than inanimate worlds fitted to sustain a Life like ours?—Far as our ken has reached between us and the HIGHEST there is still vastness and mystery:—sometimes to take wing beyond terrestrial precincts, perhaps, is not wholly forbidden; provided we go with unsandalled feet, as if on Holy ground.

Apart however from all speculation,—surely the view of an actual order whose beginnings are hid in what seems in our eye nothing less than Eternity, cannot but elevate our thoughts of that BEING, who amid change alone is unchangeable—whose glance reaches from the beginning to the end—and whose presence occupies all things! If uneasy feelings are suggested and I have heard of such—by the idea of a process which may appear to substitute *progress* for *creation*, and place *law* in the room of *providence*, their origin lies in the misconception of a name. LAW of itself is no substantive or independent power; no causal influence sprung of blind necessity, which carries on events of its own will and energizes without command. Separated from connexion with an ARRANGER in reference to whose mind alone, and as expressive of the Creative Idea it can be connected with the notion of control—Law is a mere name for a long order—an order unoriginated, unupheld, unsubstantial, whose floor sounds hollow beneath the tread, and whose spaces are all void; an order hanging tremblingly over nothingness, and of which every constituent—every thing and creature fails not to beseech incessantly for a substance and substratum in the idea of ONE—WHO LIVETH FOR EVER!

There are certain supplementary presumptions on behalf of the Nebular Hypothesis in its application to the organization of the sun, which, although out of the line of direct demonstration, are too interesting and important to be omitted here. Comprehending these remote or *constituent* phenomena of our planetary system, and therein dividing itself from all other cosmogonies,—it will appear, besides, in exquisite accordance with all known "originating principles," when we understand the especial play and influence of these phenomena on our system's destiny.—If you have rightly apprehended the cause of the stability of a planet's orbit—the balance, viz. of its centrifugal force, and the power of the sun's attraction—you will see that the influence of any *third* body upon the planet might disturb this permanence. But the idea of gravity had not long been present to Newton's mind, before he saw that as it is a universal power—a power diffused from every particle of matter within the system, enabling not only the sun to attract the planets, but *each planet also to attract every other*; so that upon each individual body—the Earth for example—there is playing, as well as the sun's attraction, the combined and ever-varying attractions of its shifting companions. It appeared to our admirable countryman, that the path of no planet could therefore be perfectly stable, but on the contrary, that every orbit must be constantly moved somewhat from its place by these unsteady influences; and he thought that the disturbances thus introduced would abate the symmetry of existing arrangements, and in all likelihood ensure their destruction by one irregular shock. The dissipation of Newton's fear was reserved for that age whose terminations we are still touching; when the subtile analysis of the illustrious LAGRANGE instructed us that every one of the disturbances referred to must be PERIODICAL or oscillatory, *i. e.* if the moon is now approaching the earth, or her orbit drawing in, a time must come when that approach will cease, and when an opposite action, or a retrograding will take place, which also will be stopped in subsequent ages by a superior limit: and so of all other perturbations. Now this truth results from the existence of *those very constituent elements of our system, which the Nebular Hypothesis alone comprehends;* for if the planets and satellites had not moved in the same direction, alike in their revolutions and rotations, and if the spheres within which they move had not approached to circles, and been comprised almost in the plane of the sun's equator—*the periodicity would not have supervened, and no antidote had been found to Newton's sorrowful forebodings.* It were pleasing here to arrest our progress and admire so signal an illustration of that beauty of design and beneficence of purpose visible in every portion of the great chain of causes and effects;

but passing the attractive theme we rather hasten to conclusions directly in view. Those constituent elements are thus the *elements of the strength* of planetary arrangements; and it is in closest connexion with *them* that we have found the originating cause of the whole planetary system. But in every department of organized life—whether vegetable or animal—it is a law that in the progress of reproduction and growth, we have an especial adaptation to produce or ensure the existence of such *essential* circumstances, while the causes of the accidental ones are evanescent and of irregular action; and perhaps it is its fine accordance with this wide and striking analogy, its adaptations to that portion of planetary phenomena which, more than all others, must have sprung directly from the causes of our system's birth, which have gained for the theory of Laplace the respect of all, and the silent acquiescence of many Astronomers.

Still farther;—the system, though strong, is not framed to be EVERLASTING; and our Hypothesis also developes the mode of the certain decay and final dissolution of its arrangements. Remember the effects of the Solar Ether! Although no mark of age has yet been recognised in the planetary paths, as sure as that filmy comet is drawing in its orbit, must they too approach the sun, and at the destined term of their separate existence, be resumed into his mass.* The first indefinite germs of this great organization, provision for its long existence, and finally its shroud, are thus all involved in that master conception from which we can now survey the mechanisms amid which we are! And mark the nature of this decay. It comes, not as Newton thought, by accident, derangement or disease, but through the midst of harmony; it is an easy consequence of the venerable power which first evolved us, infused our scheme with the spirit of life, and gave it structure and strength. Our supposed origin of the planets gave them and their satellites that kind of orbits, and that kind of rotation which produced their permanence; and the inherence of this same Nebulous parentage, viz.

* It may be asked does not this Ether rotate along with the planets and therefore not retard them? It must rotate somehow—the comets will one day discover that for us; but it cannot rotate with velocities corresponding to all the planets. Nay, the very ellipticity of the planetary orbits, small as this is, necessitates a retardation in every one of them, however the Ether may rotate.

the existence of an ether, leads gently to their decline. So dies Nature's unblemished child—the simple flower! It bursts its seed, buds and blooms; and then in unpained obedience draws in its leaves and sinks into the lap of its Mother Earth.

The idea of the ultimate dissolution of the solar system, has usually been felt as painful, and forcibly resisted by philosophers. When Newton saw no end to the deranging effect of the common planetary perturbations, he called for the special interference of the Almighty to avert the catastrophe; and great was the rejoicing when that recent Analyst, descried a memorable power of conservation in our system's constituent phenomena; but after all, why should it be painful? Absolute permanence is visible nowhere around us, and the fact of change, merely intimates, that in the exhaustless womb of the future, unevolved wonders are in store. The phenomenon referred to would simply point to the close of one mighty cycle in the history of the solar orb—the passing away of arrangements which have fulfilled their objects that they might be transformed into new.

Thus is the periodic death of a plant perhaps the essential to its prolonged life, and when the individual dies and disappears, fresh and vigorous forms spring from the elements which composed it. Mark the Chrysalis! It is the grave of the worm, but the cradle of the sunborn insect. The broken bowl will yet be healed and beautified by the potter, and a Voice of joyful note will awaken, one day, even the silence of the Urn!

—Nay, what though *all* should pass? What though the close of this epoch in the history of the solar orb, should be accompanied, as some with a strange fondness have imagined, by the dissolution and disappearing of all these shining spheres? Then would our Universe not have failed in its functions, but only been gathered up and rolled away, these functions being complete. That gorgeous material framework, wherewith the Eternal hath adorned and varied the abysses of space, is only an instrument by which the myriads of spirits borne upon its orbs, may be told of their origin, and educated for more exalted being; and a time may come, when the veil can be drawn aside—when spirit shall converse di-

rectly with spirit, and the creature gaze without hinderance on the effulgent face of its Creator: but even then—no, not in that manhood or full maturity of being, will our fretted vault be forgotten, or its pure inhabitants permitted to drop away. Their reality may have passed, but their remembrance will live for ever. The warm relationships of dependent childhood, are only the tenderer and the more hallowed, that the grave has enclosed and embalmed their objects; and no height of excellence, no extent of future greatness, will ever obscure the vividness of that frail but loved infancy, in which, as now, we walked upon the beauteous earth, and fondly gazed upon these far-off orbs—deeming that they whisper from their bright abodes the welcome tidings of Man's immortal destiny!

LETTER VIII.

SPECULATION.

If our desire of knowledge did not quicken as its sphere expands, or if Man, so long as one eminence is unsurmounted, could lay himself down in peace, satisfied with the view of the vastness and variety which already stretch out beneath him, doubtless our task had now ended, and the volume of Astronomy might have been closed. But Desire, happily insatiable, has no confine on this side the Infinite; and no sooner have we reached the elevation of one thought or idea which resolves some large portion of the unknown, than ambition is fired afresh, and speculation never at rest, takes flight towards remoter regions.

In the present instance indeed, there is every encouragement to further adventurous inquiry. The Nebular Hypothesis, in its relations to the planetary system, may be termed complete;—it comprehends its beginnings, establishes those elements on which its duration depends, and exhibits the causes and mode of its ultimate transition into a novel form; and thus—surveying it from its commencement to its close—we are as if in possession of that primeval Creative Thought which originated our system and planned and circumscribed its destiny. Now, in reference to one of these epochs, our Hypothesis seems to hold equal connexion with the whole contents of the Heavens,—the epoch, viz. of their origin; and is it—as a conclusion of our task—too daring to fancy that likewise in *their* progression under the control of law from primitive chaos, principles are evolved which regulate the existing distribution of stars into firmaments, which have determined the form of the present condition of Universe, and from which new forms will issue unceasingly, until as with the planets the hour of final transmutation comes, and the cycle of their existence is complete? In endeavouring to pursue such an inquiry—supported, as we are only by a few very remote hints from observation—there is need of all our cautiousness; nor can we hope to obtain farther than the most general idea of what DEITY keeps in store for those majestic stellar arrangements.

I. Knowing as yet only the fact, that clusters of two, three, or more orbs, provided with all the machinery of rotation and revolution, may spring from the regular condensation of a nebula around several nuclei, we cannot form an idea how, as in the planetary system, the conservative principles of the machinery will be evolved regularly and without constraint, during the formation of the cluster; nor indeed is our philosophy, boasted as it is, capable of shewing of what nature such principles are. Doubtless in those nobler systems, as well as among the arrangements of our small worlds, the elements of strength, security against shock, and fine internal compensations and adjustments, grow with them from chaos—precisely as the great oak-tree has a breathing and circulating machinery, fitted for action during a thousand years, while those of the blades at its feet decay and die after a brief summer; but we are not yet in a condition even to undertake the question, and the thought of it only stirs us with the hope of wonderful revelations to come—of brilliant records for the future pages of science. Taking, however, a very simple case, that of a regular globular or oval cluster, it is not difficult to imagine one mode, by which it might be fitted for absolute and everlasting stability. We have indeed only to suppose that every sun within it describes an oval or ellipsis around the general centre of attraction, and *all in the same time.* In whatever direction the bodies might move, whether direct or retrograde, in the same plane or across each other's orbits, such a cluster would be permanent; and during all time its orbs would thus revolve, arriving together after some vast interval at the exact position from which they departed,—which interval would be the great year, the *annus magnus* of the cluster. Now, even although no such precise motions should any where exist, this fact is extremely valuable. It illustrates the possibility of the existence of motions among the orbs of these brilliant masses, by whose relationships the influence of gravity might be permanently withstood; and it permits the conception, that whether or not that influence is *absolutely* withstood there, still such arrangements may exist, and that these clusters may be endowed with adjustments not less efficient and beautiful than the constituent arrangements of our own system, by which harmony is preserved in the face of change, and strength during a long decline.

Such a condition of stability—arising, as we will probably some time discover, also out of the very process of condensation—would not, however, be permanent or absolute, unless accompanied by an absence of all resisting causes. Should *retarding* causes exist, the recurrence of the Annus Magnus would no longer find the different orbs in their first position, but to a certain amount nearer the centre of attraction, and the whole cluster somewhat compressed: so that if any remnant of ancient chaos still pervades the intervals of these orbs, compression must ensue, and the firmament would pass through all degrees of it, occupying ages in its mysterious growth towards some other form of being. The effect of such a nebulous ether would be exactly the same as the effect of the solar ether upon the planetary orbits, so that the speculation rests solely on the question of its *existence*. Perhaps the existence of a fluid so rare may never become subject of actual or positive demonstration or experiment, unless indeed, through something like those recent notions of M. STENHEIL, which lead him to conjecture that the light of the stars does not reach us unimpaired, but that a quantity, in proportion to the remoteness of the star, is lost by passing through a certain intervening nebulous medium. Still it is fair and competent to ask, whether the *form of existing clusters* gives colour to the hypothesis of their gradual decay, or the gradual approximation of their stars. The hypothesis would clearly induce us to expect a *series* of objects, beginning with a cluster of perfect regularity, in which various compressions will be exhibited, and upon which MUTABILITY is stamped. Now, *this series exists;* if we would characterise the globular clusters we have resolved, and without reference to theory, it would be in language we have already used (see Letter V.), and by their various compressions. These objects present a series quite unbroken; and they are in the exact condition illustrated by Herschel when he compared them with plants in different stages of progress, from adolescence to proximate ripening (which in this case is decay) —precisely as Laplace afterwards most aptly characterised the varying aspects of the Nebulæ. It is not possible that these phenomena can be mere illusions. A *real* series is never meaningless; and where it seems so, we have assuredly committed the error of assuming that to be a series between whose different facts or stages there is no connexion—where we have no evidence of an evolving or transmuting cause.

—How immense is the field of contemplation opened by these very simple considerations! Even the larger forms of the Heavens are not stable! Those globular masses at least, appear in process of growth, of *ripening*—they are congregating towards that nucleus, around which the new order of things is slowly up-growing, and where the mighty orb, foretold by their progressing aggregation, is preparing to be born. I cannot avoid reverting to the notion of Mr Coleridge; what is this after all, save a prolongation of the condensing of a Nebula? Already some few of its particles have come together and formed its secondary stage; and now, that secondary stage, which we term a firmament, is passing into a third, where all the dispersed atoms will be gathered together, and lodged at the centre of the mass!

We may venture even one step higher. If the suns of each firmament, which are but the congress of multitudes of atoms originally distinct, are related in this wise—may not some similar system and similar destiny characterise Systems of Firmaments? Perhaps in the mean while these are also related, somehow as the stars in each cluster—slowly performing mighty revolutions, whose recurrence constitutes the greatest Annus Magnus of Creation—the highest unit of existing Time. Probably the elements of decay, or rather of change, are also amid this mechanism—probably all is passing, in a silence next to motionless—quietly as the leaf grows, towards some unknown consummation! The eye stretches in vain in the direction of the epochs thus foreshadowed,—they are epochs with which the duration of all we can imagine is utterly incommensurable; but yet their coming is sure; and by the existing forms and arrangements of matter their features are minutely preparing.

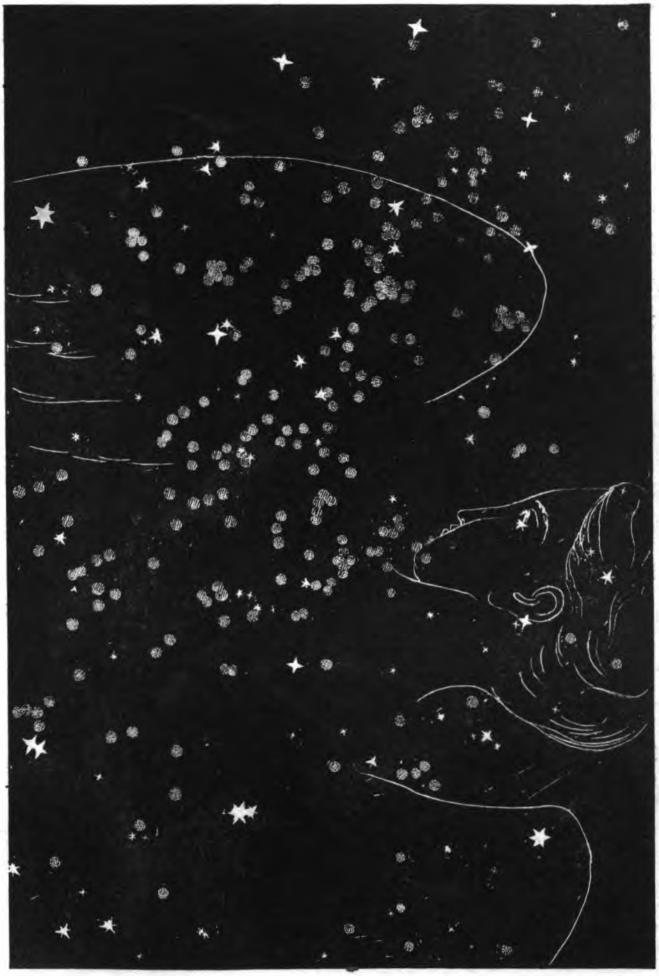
II. It is fortunate for speculations like the foregoing, that within our own Firmament, aspects are distinguishable not only sustaining them through a strong analogy, but even pioneering the way to yet bolder thoughts. Our milky zone has been already described as a ring for the most part isolated, in which the stars are very dense, and where the aggregating power has drawn them from the general mass, and by some curious operation, compressed them into a crowded girdle. But neither is this girdle uniform. In Letter V. I called your especial attention to its division, apparently into groups for the most part inclining to the spherical form, and separated from each other by dark spaces like wrinkles of age. Sir William Herschel counted no less than 225 such groups or subordinate clusters, within the extent of it he examined; and as all these were of a kind to mark the action of gravity, he concluded the existence of a clustering power, *drawing the stars of it into separate groups*, a power which had *broken up the uniformity of the*

Zone, and to whose irresistible power it was still exposed. "Hence," says Herschel, in one of those bold moments in which he fearlessly traversed the infinities alike of past and future, "Hence may we be certain that the stars will there be gradually compressed through successive stages of accumulation, till they come up to what may be called the ripening period of the globular cluster and total insulation; from which it is evident that the Milky Way must forcibly be broken up, and cease to be a stratum of scattered stars." "We may also," he continues, in the same lofty mood, "draw an important additional conclusion from the gradual dissolution of the Milky Way; for the state into which the incessant action of the clustering power has brought it, is a kind of *chronometer*, that may be used to measure the time of its past and present existence; and although we do not know the rate and going of this mysterious chronometer, it is nevertheless certain, that since a breaking up of the parts of the Milky Way affords a proof that it cannot last for ever, it equally bears witness that its past duration cannot be admitted to be infinite!" Surely the vision of these unfathomable changes—of the solemn march of the majestic Heavens from phase to phase, obediently fulfilling their awful destiny, will be lost on the heart of the adorer, unless when beneath the canopy on which their annals are inscribed, it swells with that humility which is the best homage to the Supreme!

Grounding on these sublime speculations, and taking into view some other facts, we are led to still remoter conclusions. If the aggregation of the stars in the Milky Way goes on, as it prognosticates, for Ages—the clusters, now with some intermission forming its ring, will become isolated, and appear in the character of separate systems. But, if this may happen in time future, *may something similar not have happened in time past?* And what other is the meaning of these Magellanic clouds in the south? Do they not exhibit a multitude of stars originally belonging to our system, in *the very act of becoming isolated?* Referring once more to that approximate chart in Plate II., how irregular it is, how narrow in one direction, and how ragged its edges! Can it be possible that masses of stars have been torn away from it in that direction, so that its thinness may simply indicate, that through the action of some irresistible cause, parts of it had there *ripened* sooner? Singular to relate, it is precisely towards these thin sides, and almost immediately beyond them, that the vast mass of *neighbouring* isolated clusters is found—clusters all spherical, and grouping together in extraordinary proximity. In Plate XXIII., you have part of the wing of VIRGO—a constellation situated near the shallowest part of our firmament. Observe how crowded it is with groups—some of them Nebulæ indeed, but most of them small round clusters, exhibiting a marked degree of compression. In the regions on the opposite side, the same phenomenon recurs; from which, aided by speculation, we infer that the process of separation *has gone on*, and that the apparent breaking up of the Milky Way in our time, is simply a prolongation of part of the changes of the long past, to which our capricious firmament owes its irregular form.

Collecting now those scattered gleams of truth, we reverently approach our last generalization. The separate firmaments which the telescope has descried and mapped down, shew, as has been

Pl. XXIII.



stated, even more emphatically than the groups in the Milky Way, the efficacy and progress of a clustering power;—may not *all* have come originally from one homogeneous stratum or mass of stars, so that their present isolation—their separation and various groupings, are only the ongoings of the clock—the gigantic steps of the hand, by which Time records the days of the years of the existing mechanism of the Universe! Stupendous the conception, that these great Heavens—the Heavens we have deemed a synonym of the Infinite and Eternal, are nothing after all but one aspect in which matter is destined to present itself—their history like the birth, life, the death and dissolution of the fragile plant! If this indeed is true, and on behalf of the conception we can marshal many probabilities, how immense the sphere of real existence—how little can we ever know of it; at least, how much must be referred to that higher state of existence—an expected eternity of sublime contemplation.

What wonders burst upon us! Take into consideration the influence of this vast mechanism over the minute arrangements of its subservient parts; observe the amount of most diverse organization, the almost infinite varieties of intelligence—wonderfully various, even within our limited ken—which must be attached to the progress of the Heavens, growing with them as they grow, changing during every new phase, and sympathizing with their decline:—who then shall say that even the highest created spirit will ever exhaust the fulness of that volume which God has spread before us all, in illustration of his own Infinite Nature!

—Suppose we are yet mistaken; suppose the Nebular Hypothesis, with all its grasp, not to be the true key to the mystery of the origin and destinies of things, what is gained—what new possession—by that course of bold conjecture on which we have ventured to embark? This, at least, is established on grounds not to be removed. In the vast Heavens, as well as among phenomena around us, all things are in a state of change and PROGRESS; there too—on the sky —in splendid hieroglyphics the truth is inscribed, that the grandest forms of present Being are only

GERMS swelling and bursting with a life to come! And if the universal fabric is thus fixed and constituted, can we imagine that aught which it contains is unupheld by the same preserving law, that annihilation is a possibility real or virtual —the stoppage of the career of any advancing Being, while hospitable Infinitude remains? No! let the night fall; it prepares a dawn, when Man's weariness will have ceased, and his soul be refreshed and restored.—TO COME!—To every Creature these are words of Hope spoken in organ tone; our hearts suggest them, and the stars repeat them, and through the Infinite, Aspiration wings its way, rejoicingly as an eagle following the sun.

Farewell!

NOTES.

NOTE A.

THE SOLAR SYSTEM.

The object and scope of my treatise did not admit of the incorporation with it even of a brief exposition of the phenomena of the solar system,—our contemplations inclining us to regard the sun with his attendants as one unit, and presupposing, in some instances, a general acquaintance with the system. That no doubt may rest, however, over our speculations, because of the absence of a view of the system's details, I have thrown into this note an account of most of what is important on the subject.*

1. The solar system is composed of a majestic central luminary (whose mass is made up of matter like the earth—the atmosphere alone being luminous), and a number of small engirdling bodies, which revolve around him in various periods. Toys named Orreries have generally been used to give an idea of this mechanism:—they are mere toys, often beautiful, but never instructive;

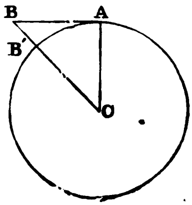
* To the full discussion of all the phenomena of that system —belonging, so to speak, to our own homes, I have devoted the volume entitled, "The Phenomena of the Solar System."

nor indeed can they be otherwise, as you will learn from the statement of the distances, and comparative magnitudes of the several bodies, which I extract from Sir John Herschel's work:—"Choose any well levelled field or bowling-green. On it place a globe two feet diameter; this will represent the SUN; MERCURY will be represented by a grain of mustard seed, on the circumference of a circle 164 feet in diameter from its orbit; VENUS, a pea on a circle 284 feet in diameter: the EARTH, also a pea on a circle of 430 feet; MARS a rather large pin's head on a circle of 654 feet; JUNO, CERES, VESTA, and PALLAS, grains of sand in orbits of from 1000 to 1200 feet; JUPITER, a moderate-sized orange, in a circle nearly half a mile across; SATURN, a small orange on a circle of four-fifths of a mile; and URANUS, a full-sized cherry or small plum, upon the circumference of a circle more than a mile and a half in diameter." Such are the contents and relative dimensions of the solar system!

2. After the labour and observation and mistakes of ages, it became a settled point with instructed astronomers, that these small bodies, including the earth, move around the sun, which is the proper centre of the system; and the question then started, in what curves or paths do the planets revolve? A decisive answer was first elaborated by the illustrious JOHN KEPLER, who not only proved that they move in ellipses, or ovals, differing little from circles, but also established a law for the varying velocity of each planet when in different parts of its

orbit, and the existence of a great relation between the distance and velocity of one planet, and the distance and velocity of any other. The three statements expressive of these general facts, are termed Kepler's Laws, and were our first accurate step towards a knowledge of the true mechanism of the Heavens.

5. After Kepler Newton arose, and completed the superstructure founded by his great predecessor. His first achievement was the combining of Kepler's three principles into one, and the constitution of dynamical astronomy. It is known as a universal fact, that bodies when set in motion tend to move in straight lines, and would so move for ever with uniform speed, provided no external force or influence interposed to deflect them from their natural paths. For instance if the body A were set in motion in the direction A B, it would move of it-



self in the straight line A B; and if we find it instead moving in the curve A B′, the inference is, that an external influence has deflected it, or turned it from its natural course; the effect of which influence in the case in the diagram, clearly is to have drawn the body (speaking *approximately*) from B to B′ in the time it would have occupied in moving from A to B. On these principles Newton resolved the orbitual motions of the planets, by referring them to two forces—their natural tendency to move in straight lines through space, and an attractive or gravitating force drawing them to the centre of the sun; and by a refined and novel method of demonstration, he proved that the attractive force exercised by the sun over the *different* planets, is precisely the *same power* diminishing in intensity in a certain manner according as the distance of the planet increases. How simple did the celestial mechanism thus become! Each planet preserves its place and rolls through its appointed orbit, in consequence of the balanced action of two simple and regular forces!

2. But Newton did not stop here. Meditating on the every-day phenomenon of the fall of a stone to the earth, it struck him that the existence of a force was here indicated, efficient in drawing bodies towards the earth; and he daringly asked whether that force diminished according to the principle he had already detected, would not explain the gravitation of the Moon? The discovery lay in the first suggestion of the idea, for the pursuit of it was not difficult. If, for instance, A B in the foregoing diagram, is the space the moon would move in a straight line in one second of time if left to her first natural impulse, and A B′ her actual orbit, the quantity B B′, which is quite susceptible of measure-

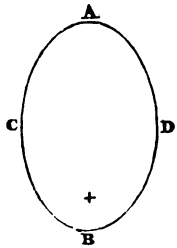
ment, will shew (approximately) the power of the earth's attraction over her in one second: and this, when placed beside the quantity through which a stone at the earth's surface falls in the same time, exhibits two motions having to each other the exact proportion required by the celestial law of gravity! It is impossible to over-estimate the value of this momentous step. It immediately *connected the celestial mechanism with terrestrial phenomena,* establishing a first analogy between the Heavens and the Earth, and yielding an emphatic intimation of the great Unity of Things. Newton now generalized his first conception; announced gravity as an universal property of matter—a law obeyed by every particle in reference to every other particle; and thus threw open the gates of the august Temple of the Universe.

Subsequent astronomers have merely applied his comprehensive principle to the solution of cosmical phenomena. The orbits of comets became at once intelligible. The figures of the planets were explained; and the determination of those fine influences, by which the planets affect each other, has constituted the chief employment of dynamical science until the present day. It is one object of my little work to collect and arrange what traces have been found of the action of the same fundamental law among the external Stellar spaces.

NOTE B.

THE ORBITS OF THE DOUBLE STARS.

The curious and inquisitive will naturally desire to obtain some notion of the actual *size* of the orbits of these double systems,—or how far one star is distant from the other. Were we acquainted with the distance of a binary system from the Earth or Sun, it would be quite easy to calculate its dimensions; but until that previous knowledge is obtained, all information derived from this source must be purely conjectural. In the *Annuaire de Bureau des Longitudes*, for 1834, M. Arago has with his usual precision detailed a very ingenious method, first pointed out by Savary, which promises to afford accurate results on the subject. It depends upon the fact that Light does not move instantaneously, but with a certain definite velocity, so that a specific time elapses between the moment when the ray leaves a luminous body and that when it enters an eye. The following considerations will illustrate the method I speak of. Suppose ACBD the orbit of a double star, whose period is 200 years, and let the star be so distant from the earth when at the points A and B of its orbit, that its light occupies two years in the first



instance, and one year in the second, in passing toward us,—what will be the effect of this upon the body's apparent motion? The result will be brought out most distinctly by calculation.

Let the star be at A in the year 1800,
It will be at B in . . 1900,
And at A on its return in 2000.

But since light occupies two years in arriving from A to the Earth, and one year in reaching us from B,

The star will be seen by us at A in 1802,
And at B in . . . . 1901.

So that it will seem to have performed one-half of its revolution, or to have gone through the half ACB of its orbit in *ninety-nine* years.

Again,

It is seen at B in . 1901,
And once more at A in . 2002.

So that it will seem to have revolved from B to A, or to have gone through the other half of its orbit BDA in *one hundred and one* years. But as it really does pass through these two arcs in precisely the same time, this apparent difference of its periods must be owing to the *size of its orbit as measured by the velocity of light;* and in fact half the difference of the two numbers 101 and 99, or one year, *is just the period occupied by light in traversing the distance from A to B.* The rule is quite general: observe the apparent times occupied by any revolving star, in going through the two halves of its orbit; and half the difference of these times will be the period in which light passes through the diameter of its orbit; and as the velocity of light is known, that diameter may therefore be computed in miles. The only obstacle to the general application of the method consists in the difficulty of noting exactly when the star is at the two opposite points of its orbit; but notwithstanding of this difficulty it will yield results accurate within certain limits. It is impossible to give too much credit to the ingenuity of M. Savary.

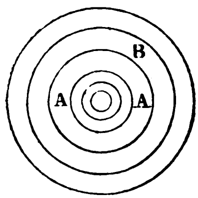
NOTE C.

RELATION OF THE NEBULAR HYPOTHESIS TO GEOLOGICAL CHANGE.

I MEAN to compress into this Note a few remarks at one time destined for the text, regarding the influence which may be exercised by the Nebular Hypothesis over the course of geological speculation.

It does not require notice that our Hypothesis supplies the matter of the planets, &c. in a condition sufficiently plastic to permit of its taking on the precise form in each case, which a solid of revolution ought to have; nor indeed is this of any considerable moment, inasmuch as a great number of hypothetical cosmogonies offer similar facilities. When we go farther however, and trace the subsequent physical history of the bodies thus fashioned, we discover peculiar adaptations of our theory to the solution of problems which pure geology has not hitherto comprehended, and in regard of which that science must sooner or later borrow aid from Astronomy. The causes of geological change are two—an *abrading* and *levelling cause,* operating chiefly on the surface of our globe through the agency of running water; and an *elevating cause*—that which has upheaved our mountain masses, and which is still efficient not only in partial volcanic actions, but over large tracts of territory, such as Sweden, which are slowly but gradually rising to a higher elevation. The difficulty in geology is to discover the nature of this elevating cause, and it is with this question, as well as the mode of its operation in time past, that the conflict of geological theories is now concerned.

We enter on the subject most easily and naturally through Dr Daubeny's theory of Volcanoes. It is well known that the metallic *bases* of the earths, alkalis, &c., inflame with considerable deflagration on contact with water; and this philosopher supposes that masses of these unoxidated metals lie beneath the surface of the earth in subterranean reservoirs, to which water from the surface may find occasional access, and cause an explosion. Chemical objections have been alleged against this theory, but they are of no cogency; and I believe that existing volcanic phenomena receive from it the best and most logical explanation which has yet been proposed. Let us now express this theory in general language having a view to the Nebular Hypothesis. Our world is in that epoch of its being which, physically speaking, may be termed the *epoch of the fluidity of water*, and we find that this water, which is the nebulous bed or stratum last condensed, exerts chemical actions upon the previously condensed bed of so violent a nature, that deflagration and explosion issue from their fortuitous meeting. How easily is this theory extended! In its very nature it points to a general law; for what is going on with regard to these two most recent beds, may have supervened through all time past with any two strata which came in contact: the stratum B, in every stage,



may have had chemical relations with the stratum A, so that *a deflagrating and elevating power may have characterised every epoch of the history of every planet.*

When Daubeny's theory has received this general expression, the knot is cut which so much puzzles geologists of the present day, regarding the comparative extent of modern and ancient volcanic forces. Mr Lyell has achieved a great philosophical reform in this department of inquiry, in boldly asserting it as a fundamental tenet that we must philosophize upon the ground of existing and known forces; but when he passes beyond this, and denies the possibility of the superior energy of these forces in former epochs, he oversteps his limits, and *dogmatizes*,—because it is only when the nature of the *origin* of the force is comprehended, that we can ascertain whether or not it is plastic. The Nebular Hypothesis, as above, provides for its variability; and existing astronomical phenomena seem to establish that it *is* variable.

It has long been known that the elevating cause—whatever it is, is not peculiar to this Earth;—its operations are seen in the Moon, in Venus, Mercury, and perhaps also in the Sun. Now, there is an order of age among these celestial bodies. Of the planets, the eldest is the farthest off, then comes Saturn, afterwards Jupiter, the four Asteroids, Mars, the Earth, Venus, Mercury; and the Satellites considered as complete worlds, are perhaps the most recent of all. The inspection of the different planets then, shews us this elevating cause in operation in a considerable variety of epochs, and we find, that the more advanced or the older the planet, the less rugged or mountainous is it—the less energetic this shattering power. Saturn and Jupiter show no appearance of mountains; those of Venus, and in all probability of Mercury, are gigantic, when compared with the existing elevations of the Earth; and when we reach our own Moon, we find a picture of that torn, crateriform, and disturbed surface, which our own earth may have exhibited when the masses of existing mountains were thrown up, when the pinnacles of the oldest ranges were unabraded, and the ruggedness of the valleys not yet smoothed away by the levelling power of the fluid which deposits and stratifies there, the detritus of the primary rocks.

It is much to be wished that when a science arrives at its ultimate problems, we would no longer study it in isolated fashion, but look abroad through the Universe, for those relations which constitute it a part of the grand whole.

NOTE D.

LOCALITIES OF THE PRINCIPAL CLUSTERS AND NEBULÆ.

I subjoin a statement of the exact places of the more important objects represented in the foregoing plates; so that the possessors of good telescopes may have the opportunity of examining such as are within their reach. I give their Right Ascensions and Declinations, by means of which their localities among the stars may easily be detected upon a celestial globe, and thus found without difficulty in the Heavens.

	Right Ascen. H.	M.	Declinations. Deg.	Min.	
Plate I. Cluster in Hercules,	16	35½	36	45	N.
Plate III.	13	22½	46	14	N.
Plate V. Fig. 1, . . .	15	10	2	44	N.
Fig. 2, . . .	21	25	1	34	S.
Plate VI. Fig. 1 (counting from the left top of the line and passing across the page) 30 Doradûs,	5	39½	69	15	S.
Fig. 2, . . .	0	16½	73	0	S.
Fig. 3, . . .	21	31	23	55	S.
Fig. 4, . . .	15	29	6	33	N.
Plate VII.	4	55	72		

	Right Ascen. H.	Right Ascen. M.	Declinations. Deg.	Declinations. Min.	
Plate VIII. Fig. 1, faintest of the two rings, .	20	9½	30	3	N.
Fig. 2, brightest of two rings, . .	18	47	32	49	N.
Fig. 3, oblong hoop,	2	12	41	35	N.
Fig. 4, oval figure beside the hoop,	12	48	22	37	N.
Fig. 5, large figure,	19	52	22	16	N.
Plate XIII. Nebula in Orion,	5	27	5	30½	
Plate XIV. Fig. 1, Nebula in Andromeda,	0	33½	40	20	
Plate XV.					
Fig. 2, . .	20	38½	30	6	N.
Fig. 3, . .	20	49	31	3	N.
Plate XVI. . . .	18	11	16	15	S.
Plate XVII. Double Nebulæ,	9	22½	22	15	N.
	7	15	29	49	N.
	22	51	13	43	S.
Two stars on faint bed of light,	18	7	19	56	S.
Plate XX. Nebulous stars,	17	0	23	7	N.
	19	40	50	6	N.
	3	58½	30	20	N.
Plate XXI. Reticulated form,	20	50	29	34	N.
Nebulous matter connected with stars,	12	51	35	47	N.
	20	56	11	24	N.
	6	30	8	53	N.
	8	46½	54	25	N.

ADDITIONS AND CORRECTIONS.

Page 41, line 7 from the bottom, *for* they *read* they are

... 66, line 13, *for* or nearly *read* as nearly

... 70, line 11, *for* nearest *read* closest

... 80. It ought to have been mentioned here, that the decimal places after the *year* in the table, indicate the time of the year, or the *date* when the observation was taken. For instance, 1838.5 would signify the exact middle of the year 1838. And so of the other parts.

... 83, line 2, *for* according *read* according to

... 84, line 5, *delete* the *before* observation

... 128, line 10, *for* cirrhous *read* cirrous

... 194, line 4, *for* STENHEIL *read* STEINHEIL

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