FAMILIAR

9.1830

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ASTRONOMY.

BY GEORGE DARLEY, A. B.

AUTHOR OF A SYSTEM OF POPULAR GEOMETRY,

ALGEBRA, TRIGONOMETRY,

&c. &c. &c.

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PREFACE.

WITH a little more truth than perhaps the assertion in Tales and Romances can frequently boast of, it may be said, that the idea of the present Work is "founded on fact." The Author was, literally, put to the Question, as described in the following pages, by five persons of the sex, age, and condition, therein given to be understood. These individuals happily, though accidentally, represented those Classes of Society for which such a Work is desirable, *viz.* Persons too advanced in life for regular Instruction, though anxious for casual Information, especially on the subject of this Treatise; Young Ladies who, however solicitous for knowledge, would rather find it by conversation than seek it by study; and Boys, whose natural inquisitiveness, rather than love of inquiry, prevents their remaining in contented ignorance, to which they would otherwise be doomed by their idleness.

was natural to suppose that what proved sufficiently agreeable to the Representatives, would not prove unacceptable to the Classes themselves; and accordingly this little Treatise is published with a view towards more general entertainment of a useful kind than was contemplated by the familiar discourses on which it was founded. We have Astronomies, perhaps more numerous than is necessary, both of a very puerile and a very profound nature; but we have few adapted for that extensive circle of Readers who are neither mere children nor mere scholars. To how many individuals of society would "Conversations between Mrs. D., and George, Mary, &c." appear rather unsuitably didactic, and yet even FERGUSON himself too scientific? There is a species of astronomical work half way between these, neither childishly superficial nor scholastically abstruse; neither a catalogue of bare facts nor dry reasonings, which seems best fitted for the Classes above mentioned. Of this species, and of it only, our FAMILIAR ASTRONOMY pretends to be.

Although, as we have said, the idea of this Work was suggested by fact, it is not of course to be understood that more than the mere idea is taken from reality. Most people are aware how ill family conversations would *print;* and few are willing that their characters, however unimpeachable, should be made public. On this account, neither the incidents, persons, nor dialogue, of our little Astronomical *Drama* are to be taken as likenesses, unless very remote, of their prototypes; they have hardly more resemblance to the actual incidents, persons, and dialogue, than the ramified expansiveness of an oak has to the small rotundity of an acorn from whence it has originated.—This notification is requisite to prevent misconceptions.

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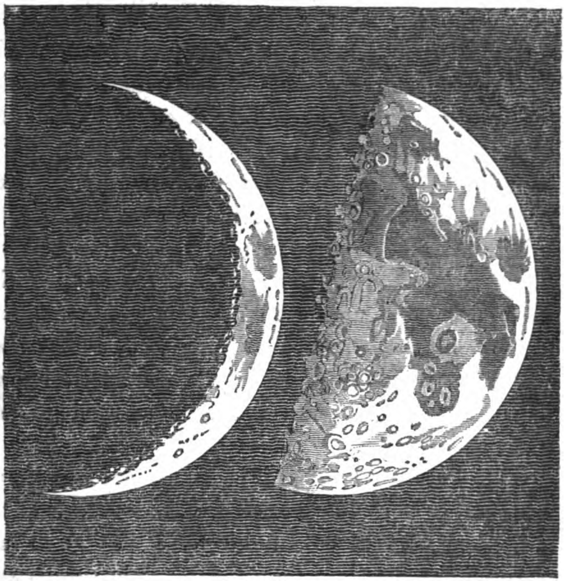


INTRODUCTORY EVENING.

I HAVE always found, said Colonel St. George turning about to Franklyn, that what I hear makes a deeper and more lasting impression on my mind than what I read. This, too, I believe, is the case with almost every one; and it is therefore a matter of astonishment to me, that the system of instructing by conversation is not universally pursued throughout our academies, public as well as private.

It should be combined with study, I think, replied Franklyn after a few moments' consideration; for though it might be granted, that in general we hear with deeper interest than we read, yet we are apt, in the rapidity of conversation, to let things go by without scrutinizing them sufficiently. On the other hand, when we read, we have time and presence of mind to examine.

The system, no doubt, said the Colonel, has, with many advantages, some disadvantages, which are to be made up for in the way you mention. But, at all events, our gratitude is due to those estimable members of society, such as Bell and Lancaster, who have introduced the method of Oral Instruction.

"Oral Instruction," as it is called, may be traced perhaps to the remotest antiquity, observed Franklyn. Indeed, there can be little hesitation in ascribing its origin to the patriarchs: inasmuch as, before the existence of books, or written knowledge, how else could facts be communicated?

This seems to confirm an observation I met with this morning, rejoined the Colonel, that modern inventors are, for the most part, only discoverers of ancient discoveries. These they seek, or meet by accident, in obscure and abstruse works, and immediately produce them in a new form as their own.

Reaping a harvest of credit where they did not sow a grain of genius, added Franklyn.

But assuredly, said Eugenia, it would be unfair to institute any comparison between Dr. Bell's system and that of Abraham or Noah, because they taught their children orally.

Not only unfair, but absurd, replied Franklyn. Though, in many of the cases to which your father alludes, books have been broken open for the mere purpose of stealing their contents; and, as Dogberry says, "flat burglary as ever was committed" is in this manner perpetrated daily; nevertheless, in many others, we have been indebted to the ancients for little more than a bare hint, of a very simple kind, which by our own ingenuity has been expanded into a comprehensive system.

With regard to the peculiar method of instruction denominated Lancasterian, this may be, and I believe is, very true, said the Colonel; but from what you yourself observed, I cannot help thinking that Dialogue must have been both a very early and a very general vehicle of instruction.

It is certainly the most easy and the most natural, added Mrs. St. George.

Every one in the slightest degree acquainted with the customs of antiquity will bear witness, said Franklyn, to the use of Dialogue for the purpose you specify. I never meant to deny a fact so well established. Its existence as a patriarchal custom we may infer from various passages in the Bible: and that it was likewise the favourite mode of instruction adopted by the heathen philosophers, no one who has read the History of Greece can be ignorant. Nay, it was so general and popular, that the phrase, "to have *heard* Socrates," or, "to have *heard* Plato," was equivalent to declaring, that the *hearer* had been *instructed* by the philosopher mentioned.

Did Socrates and Plato, then, keep *schools?* inquired Reginald.

Each was indeed the head of a school, answered Franklyn, but not exactly of such a school as you go to. For, in the first place, their pupils were all grown men; and, in the second place, there was no school-discipline among them; but they sauntered about with their master, listened or not as they chose, and frequently started objections, or asked questions, which he answered—if he was able.

What a pleasant sort of a school! exclaimed Reginald; I wish Eton were such another!

Besides many other differences, you are also to observe, continued Franklyn, that a person might belong to one of these ancient schools without ever having *seen* the master, but merely by adopting his opinions. On the other hand, a person who had both seen and heard the master might not belong to his school, if he chose to dissent materially from his opinions. Thus, Cato, whose opinions you may find in a tragedy written by Addison, was of the Stoic school, though he lived two hundred years later than Zeno, its founder; and Aristotle, the tutor of Alexander the Great, though a "hearer" of Plato, was himself the head of a totally distinct school—the Peripatetic.

A most singular name for a sect of philosophers! observed the Colonel: it refers, I suppose, to the custom of sauntering about during lecture, which you just now spoke of?

So the learned conjecture, replied Franklyn: the two Greek words *peri*, about, and *pateo*, to walk, making up the term *peripatetic*: though some derive it more immediately from the *Peripaton*, a sort of promenade at Athens, where these philosophers used to assemble.

And from what is the word *Stoic* derived? inquired Isabel.

From *stoa*, the Greek for a porch, because it was in a magnificent open portico at Athens that Zeno chose to walk with his disciples.

What a dignified and yet affable way of communicating knowledge! said Eugenia. How much more attractive than the formal system which prevails in our academies; nay, in our public lectures, where the teacher alone speaks, and that too from a stage or a pulpit!

I agree with Eugenia, said her mother; and am unable to conceive any thing more truly grand, more venerable, or indeed more picturesque, than one of these majestic sages leisurely walking through the marble colonnades and porticoes of Athens, while he calmly discourses on the sublime truths of philosophy, with a crowd of ingenuous youths accompanying him.

There was a noble simplicity about the ancients, which threw an indescribable air of grandeur over their most familiar actions, said Franklyn. Plato held his discourses in the gardens of Academus, thence denominated the Academy; a place without the walls of Athens, where he wandered, or reposed, beneath olive and myrtle shades, with his pupils, and poured out his divine eloquence by the murmur of a fountain, or uttered his sweet instructions amidst the perfume of a thousand odorous shrubs by which he was imbowered. With such accompaniments, how lovely must the voice of Wisdom and Philosophy have sounded! And who so dull, or so depraved, or so indolent, as not to listen to it with rapture!—In this manner were the profoundest truths of Science, the gravest maxims of Virtue, and the most sublime theories which Imagination could suggest, inculcated as *familiarly* as we now talk in this orchard!

I wish!—I wish, said Eugenia with enthusiasm, that as *we* saunter about these beautiful moonlit walks, you would fulfil your promise in the same manner!

What! in the manner of *Plato?* said Franklyn gravely. Your request is so moderate, that of course I have nothing to do but comply with it immediately.

You understand me well enough, replied Eugenia laying her hand on her cousin's shoulder. What I mean is, that in the unrestrained natural way of conversation, while we take our evening walks among these glimmering shades, and beds of flowers, and smooth green alleys, you would give us some insight into the Principles of Astronomy, instead of, as we intended, holding a formal lecture in the library.

Here Isabel and Reginald added their prayers to Eugenia's request. Their cousin either was, or pretended to be, inexorable. Neither Colonel nor Mrs. St. George said a word, although both looked with a smile of approbation on their children's anxiety for instruction. At length Franklyn appeared suddenly to have altered his mind.

Well, said he, on these terms,—that it is to be a *conversation*, and not a *formal* lecture, or *disquisition*, in which I am to play the part of a dogmatic philosopher,—I am prepared to do as you require.

Let it be so then, said the Colonel; and nothing can be more favourable than this opportunity, as we shall have moonlight during the whole time of your stay with us.

How beautifully it now glimmers through the foliage! exclaimed Eugenia. See how it chequers the pathway before us, and spreads with a gentle brilliancy over the green.

Who would suppose, said Franklyn, that such a sweet bright light came from a body as dull and dense and dark as the earth we inhabit?

And is the moon so? inquired Eugenia with an air of disappointment. From the clearness and delicate splendour of her appearance, I had concluded that her orb, however dense, was composed of a far purer material than earth. Nay, we are told that the moon is a dwelling-place for beings of a higher and more refined order than we are; and that the nature of the sphere accorded with that of its inhabitants.

Poetry would teach us to indulge such a belief, said Franklyn; but, alas! Science tells us that it is an illusion. I am not sure that we are much indebted to Science on this score, though on so many others. At least, for my own part, I acknowledge having sometimes caught myself on the brink of an involuntary sigh, when, after having wandered in oblivious enthusiasm amongst these sublime scenes created by the pencil of Imagination, they have suddenly vanished, as the light of Truth broke in upon them. At such times I have been ready to admit the threadbare maxim of our poet, "Where ignorance is bliss, 'tis folly to be wise!" or to exclaim, with the Roman philosopher, when he contrasted the sublime theories of Plato with the matter-of-fact statements brought against them by others—

"Errare mehercule malo cum Platone, quam cum istis vera sentire!"
I had rather err, by Hercules! with Plato, than think aright with these!

But, setting poetry aside for the present, the fact is, that the moon, to a degree of probability not questionable, nearly resembles the earth in texture and materials.

How can that have been found out? demanded Isabel.

That she is *opaque*, or, in other words, *not transparent*, answered Franklyn, is evident from her appearance at the time of an eclipse: she then looks like a dusky brown iron plate, of huge dimensions, suspended immediately before the sun, not one of whose rays passes through her body.

I remember perfectly her appearance during the last eclipse; it was just such as you describe, said Isabel; only that we did not see the entire ball, but merely a part, which seemed to glide over the sun.

And that she is not *only* opaque, continued Franklyn, but *earthly*, is rendered almost a matter of ocular demonstration by means of our telescopes, which bring her apparently so near that we can discern the very inequalities on her surface. These reflect lights, throw shadows, and exhibit various other phenomena perfectly similar to those of mountains, rocks, and valleys, upon earth.

Why, then, in fact, exclaimed Reginald, the moon is another earth!

Either that, or something very much akin to it. And, to increase your astonishment, the planets likewise are, each and all of them, earthy in their form and substance; at least display, under every aspect, earthlike appearances.

Is it then supposed that they are inhabited by human creatures? inquired Mrs. St. George.

It is *supposed* so; and on the very probable grounds that terrestrial spheres should have terrestrial inhabitants—if *any*. But at all events, that they are tenanted by *rational* beings of some kind, if not exactly of ours, seems to be most consistent with the love of creating "in his own image" ascribed to the Divinity.

This reminds me of Fontenelle's "Plurality of Worlds," said the Colonel; which I read a great many years ago.

Little more is absolutely known on this subject, observed Franklyn, than when Fontenelle wrote the brief astronomical tract you mention; and, perhaps, little more will ever be known. It is all mere conjecture, however reasonable. We have no telescope powerful enough to show us a "man in the moon," as well as a mountain.

If it be true, said Isabel looking up to the golden-spotted firmament, how wonderful to think of all these stars being peopled by creatures like ourselves!

You forget, my dear girl! said Franklyn smiling, that I confined my assertion to the *planets*. Very few of those luminaries which we behold are planets; indeed but *ten* out of the whole number visible in either hemisphere enjoy that name. The rest are all *fixed stars*.

"*Fixed!*" cried Reginald. Do they not every one of them move round the sky? That very bright one, which is now directly over our heads, was far behind us when we first came into the orchard. Isabel and I remarked it.

But can you not conceive an object to move, and yet be fixed at the same time? demanded Franklyn.

Impossible! said the boy with a smile of the utmost incredulity.

Suppose a two-masted vessel to sail before the wind from a promontory on which you stood, said Franklyn placing the forefinger of one hand in the palm of the other: why does not the hind mast, which bears the brunt of the gale, overtake the fore mast?

Why, because it is fixed in the deck! said Reginald laughing.

That is enough! rejoined Franklyn also laughing. Here, by your own confession, is an instance of a fixed body moving: the mast, which is fixed as regards the deck, moves along with the ship as regards the promontory on which you stand.

Yes, yes, said Reginald half blushing, but is that the case with what you call the fixed stars?

Exactly. They keep the same distance with respect to each other, like the hind mast with respect upon it. Suppose each of these seven little asterisks (*) a star.

Now, look pretty high up in the heavens, and tell me if you can discover seven real stars, arranged pretty nearly in like manner.

There! after some pause, exclaimed two or three at once. There are seven large stars, forming exactly the shape on the gravel!

That figure, then, said Franklyn, is called, from its shape, *The Plough*, or *Charles's wain*,—properly *Churl's* wain, from *Ceorl* the Saxon for a husbandman. You perceive that the four right-hand stars somewhat resemble the body of a waggon, and the three others its yoke or beam.

I have often heard of this, said Isabel, and am glad I now know a way to find it.—But what does the little *cross* you have made on a line with, and above, the two hindmost asterisks signify?

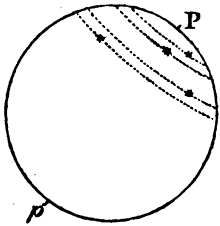
Look along the two corresponding stars in the Plough, beginning from the bottom, and see if, at about five times their distance from each other, you cannot discover a smaller star.

Yes! there it is! exclaimed all.

Remark that star particularly, said Franklyn; it is the pivot of the universe.

What do you mean? inquired the anxious circle of listeners.

This, replied Franklyn. If you observed the heavens for a sufficient length of time, you would perceive all the other luminaries to revolve, or wind in circuitous paths, round that one which I told you to remark, whilst *it* remained immovable. Just as if you



painted several little asterisks on a blue ivory ball, which revolved on the pivots P and *p*: these asterisks would move round the pivot P, each on its own dotted line, while the pivot itself remained in the one place. Now, from this circumstance the pivot-star aforesaid is called the *pole*-star, because in Greek *poleo* signifies to turn, and the whole sphere of the universe appears to turn on that pivot.

Then, is this the *North Pole*, by which sailors steer their vessels? asked Reginald.

The same, as they designate it, replied Franklyn, and if there were (which there is not) a star similarly placed at the opposite point of the heavens, as at *p*, that would be called the *South* Pole-star. Observe, however, that the pole-*star* and the *pole* are not exactly the same thing.

Is that so? inquired the Colonel. I have always heard these two words used synonymously, and I have made many voyages.

They are usually confounded, replied Franklyn: I did so myself this moment, when I talked of the pole-*star* being the pivot of the universe. Now, the fact is that the pole-star is only thus called from its being the nearest visible star to the point or pivot itself, about which it, like the other stars of the firmament, revolves, though in a very small circle. To be more accurate then, the *North Pole* is that imaginary point in the heavens round which the heavenly bodies appear to move every twenty-four hours, but which is itself immovable.

As the transformed weaver in the Midsummer's Night's Dream says to fairy Cobweb,—"I shall desire more of your acquaintance, good master" Pole-star! said Isabella.

And I too, said Eugenia. By the assistance of this bright little gentleman, I have been able to reduce the stars into some kind of order: they now appear to tread their mystic rounds with a good deal of regularity; and their number is, I perceive, by no means so great as I had imagined, before you told me how to arrange them.

Still, exclaimed Mrs. St. George, they are many and splendid enough to render a night like this even more sublime than the proudest day, when the sun himself is arrayed in all his glory. I do not wonder that poets are so fond of describing night scenes, nor at the more intense adoration which they pay to the moon than to her brother luminary.

It has always appeared to me, said Franklyn, as a trait of refinement in the disposition of Caligula, —if I dare not adduce it as a proof that he was capable of tender emotions,—his ranging by night through the imperial gardens, and wooing the moon to be his mistress.

What is it Lorenzo says to Jessica, in the Merchant of Venice? murmured Eugenia endeavouring to recollect the verses.

It is an exquisite passage! said the Colonel. I wish some one could remember it.

Franklyn repeated:

"How sweet the moonlight sleeps upon this bank!
Sit, Jessica: Look how the floor of heaven
Is thick inlaid with patines of bright gold!
There's not the smallest orb which thou behold'st,
But in his motion like an angel sings,
Still quiring to the young-eyed cherubims:
Such harmony is in immortal souls."

There are two or three questions I much wish to ask you about that passage, said Isabel, which I have often admired without fully understanding it.

In that, I believe, you are not singular, dryly observed Franklyn.

First; what is the meaning of the word "*patines?*"

Plates, said Franklyn, or small flattish vessels, frequently of precious metal, used at table by the Romans. The word seems to be derived from the

Latin verb *pateo*, which means to spread out; because these vessels were shallow, and wide in proportion to their depth. It is not improbable that our English word *pan* may be a contraction of *patine*. Johnson defines patine, "the cover of a chalice." By the by, young ladies would find a *Dictionary* of great use in enabling them to understand Shakspeare as well as to admire him.

Come, said Isabel, you need not pretend to be so very severe and sententious. But I know you too well to be *much* afraid of you.—However, I now perceive the beauty of Shakspeare's imagery: he likens the stars to so many bright little plates, or salvers as it were, of gold.

And are they *really* such flat, little, salver-like things, as Isabel says? inquired Reginald.

As far as is known of them, quite otherwise, replied Franklyn. They are, in all probability, round, like your ball, and a great many times larger than the earth we live on.

Then why do they seem so flat and small?

Because of their immense distance, answered Franklyn. If you throw your ball very high into the air, it will appear gradually diminished to a mere speck, and will at length, as you would say, "go out of sight,"—that is, will become so small as not to be discernible.

Yes, but it would never appear *flat*.

You *know* it to be round, and therefore always judge it to be so, whatever it may appear. But if you did not know it to be round, it certainly would appear flat, as the moon does, which we are nevertheless certain is globular. Yet she is not so distant, by many millions of miles, as the nearest fixed star.

Millions of miles! ejaculated the boy. Why, they all seem to be at the very same distance in the sky!

When I was of your age, Reginald, said his father, I thought so myself. But do you not observe how the moon glides over that star just vanishing beneath her edge?—There! it is gone!—You must see from this that the moon is between us and the star.

Yes, but, papa, observed Isabel shrewdly, if it were only its own *thickness* nearer, it would glide over the star as well. How do we know that it is so very much nearer as Franklyn says?

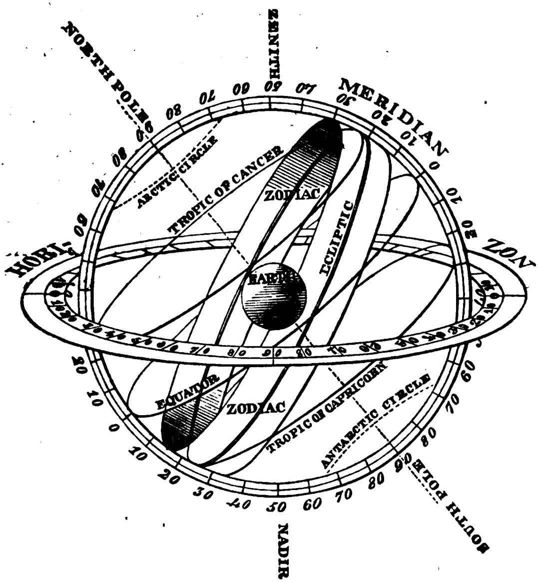
You must ask him, my love, said her father, if you wish to be an astronomer. When you wish to be a *soldier*, come to me.

'Pray, Colonel, said Franklyn, do not direct Miss Isabel to me as to an astronomer: I am none. I profess myself only a lover of the sciences, and of it especially, as the most sublime, interesting, and wonderful. My academical duties have led me to study it with perhaps more than common attention; and knowledge is like water, which it is a kind of impiety, or at least a great inhumanity, to deny those who thirst for it, if you have any to afford. I shall be always ready to unlock my little fountain, and disperse it in cups to the bystanders who may ask for what I deem of so little value, except as it gratifies them. But do not, I beseech you, call me an astronomer!

The Colonel laughed, and gave his promise to be more circumspect.

But you have not answered me my last question, said Isabel to Franklyn, and you know I have a great many others to ask you.

To-morrow night, my fair cousin! said Franklyn, taking both her hands in his: but listen!—the supper-bell strikes! and I never spoke so eloquently yet, that I would not much rather have heard its tongue than my own.



EVENING SECOND.

How delicious the air is! how refreshing after the sultriness of noon! exclaimed Mrs. St. George, as the party issued next evening into the orchard.

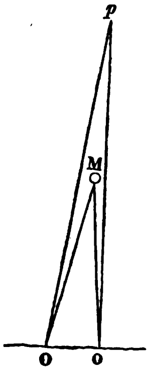
Burning days make balmy nights, observed the Colonel: that is an old maxim of rural experience.

The moon had not yet risen, but all joined in praising the soft radiancy which a thousand stars threw over the earth, and in preferring it to the glare of day.

Ay! muttered Franklyn gazing at the brilliant assemblage; these, as poor Lear said of his daughter's eyes, "do comfort and not burn."

That is because they are so very *distant*, I suppose? observed Isabel with a sly allusion to the promise of last night.

True, said Franklyn; for the fixed stars are, in fact, all of them *suns;* and, being so, you may think what an oven the world would be, unless they were at immeasurable distances from one another! —Observe now what I am about, continued he, drawing a figure on the gravel: Suppose O and



o the places of two spectators on the earth, M the moon between and above them; likewise, suppose OM, and *o* M, to be the lines along which these spectators view the moon, respectively: the width between MO and M *o*, at the moon, is called an *angle;* and with reference to the interval O *o*, it is called the angle *spanned by the interval* O *o*. Now, by means of a process which I will explain hereafter, we are able to calculate the *size* of this angle, in the case of the moon. But if we suppose the moon to be drawn backwards from

O *o*, into the position *p*, it is evident that the angle spanned by O *o* would become smaller, and the lines O *p*, *o p*, would approach each other. This is actually the case with a *planet:* if we calculate the size of the angle spanned by O *o*, at a planet *p* next the moon, we should find it to be much smaller than the angle spanned by O *o* at the moon; which shows that the planet is at a greater distance from the earth than the moon. But as to a *fixed star*,—if we attempt to calculate the size of the angle spanned by O *o* at this, we find it so small as to elude the utmost nicety of our process. Hence, the star must be farther off than either the moon or a planet; in short, must be at a comparatively infinite distance.

Then, if the *fixed stars* be so very much farther than the planets, said Isabel, *why* do they all appear of the same size?

I do not think they *all* appear of the same size, observed Eugenia: for example, the *pole-star* is evidently much smaller than any of the stars which compose the *Plough;* and of these, the nearest to the pole is by much the largest.

All those fixed stars which are visible to the naked eye are divided into *six* classes, according to their different degrees of *brightness*, said Franklyn; for as to *size*, they exhibit no sensible magnitude whatever, being mere points. It is only from their tremulous appearance, occasioned, it is thought, by the vibration in our own atmosphere, and from the rays of so many falling at once upon our eyes, that we are led to think them of *any* perceptible breadth. To convince yourselves, look through this long roll of paper at the very *largest*, as you call it, and you will see it as a mere speck, if you can see it at all.

Now that I see only the direct rays from the star, admitted Eugenia looking through the tube, it appears almost indistinguishably small,—indeed a mere luminous point. But then, said she turning the paper to another star, that which I saw here just now has vanished entirely! Does not this prove it to be yet smaller than the other?

No; it only proves that it is less *bright*. For if you admit that the first star you looked at was a mere point,—and of no distinguishable size,—it is a contradiction to assert that the second is "yet smaller." How can it be smaller than that which has no size? But if we *suppose* the magnitudes of the stars to be in proportion to their *brightness*, then indeed we may reckon six different classes of magnitudes; thus:

There are 11 stars of the first magnitude, *i. e.* of the first degree of brightness, visible in our hemisphere; about 50 of the second magnitude; and about 120 of the third. All the rest are stars of the fourth, fifth, or sixth magnitude.

Show me a star of the first magnitude! said Reginald eagerly.

Suppose a line drawn from the uppermost hinder star of the Plough, and continued between and beyond those two stars which form the front. Now, look along that line, and the first very remarkable star you come to, at about *four* times the length of the Plough from its front, is a star of the first magnitude.

I see it! cried Reginald. It is amazingly bright!

Astronomers call that star, continued Franklyn, *Arcturus*; a Greek word, compounded of *arctos*, a bear, and *oura*, a tail; because the *Plough* is otherwise, with its adjoining stars, denominated the *Great Bear* (in Latin *Ursa Major*), and this star was considered as its tail, or rather—*tail-bearer*.

There is a pretty mythological story connected with these stars. Jupiter, travelling in Arcadia, falls in love (as he was very prone to do) with Calisto, daughter of the king, and one of Diana's attendants. Juno discovers the circumstance, and transforms the luckless nymph, out of particular spite we are to suppose, into a *bear*. As some consolation, however, she, together with her son Arcas, is translated by her omnipotent lover to the skies, which were the common receptacle of all such unfortunates, into whatsoever hideous shapes metamorphosed. There she continues, under her degraded form, to wander round the skirts of the polar regions, being prohibited, at the instance of Juno, from ever approaching the warm south; or, as Ovid says, from contaminating the pure waters of ocean, into which other stars are permitted to descend after their nocturnal peregrination.

Into the ocean? repeated Isabel, with surprise. Surely that is impossible!

Indeed it is so, answered Franklyn; but in ancient times, when some of the wisest philosophers were more ignorant of terrestrial geography than a modern schoolboy, great mistakes were committed in astronomy. It was then supposed, that the Earth was nearly a perfect *flat* surface, the land portion of which was collected in the middle, while a surrounding ocean stretched illimitably to the sphere of the stars. On this hypothesis, it was consistent enough to believe that several of these luminaries which we now behold, nay the blessed sun himself, rose from the great circumfluous ocean, and set in it likewise. Especially as they *appeared* to do so, and we all know how apt human nature is to judge from appearances.

How soon was the truth discovered? said Eugenia.

Why, about the exact time there is some obscurity. It is generally supposed that the true system of the world, according as it was suspected by Copernicus, the Prussian astronomer, in 1543, and demonstrated by Newton in 1687, had not been wholly unknown to Pythagoras, the Grecian sage, who flourished about 550 years before Christ. Various others, since that time, have, in various ways and degrees, approached the truth: one error has been corrected in one age, and another in another. But, until the age of Copernicus, men in general were so unacquainted with what our old friend, Ephraim Jenkinson, in the Vicar of Wakefield, would call the *cosmography* of the world, or, in other words, its true system of arrangement, that such poetical expressions as Ovid makes use of above, were neither revolting to common sense, nor in opposition to common knowledge.

Of course, observed Colonel St. George, men could *know* of these things only as far as they had seen; but I do think that it was not a little revolting to common sense, the fable of an ocean which encompassed a small circle of dry land, stretching thence illimitably to the stars. No one who reflected a moment could believe such absurdity!

My dear sir, replied Franklyn, be assured that this theory only appears so very ridiculous, because of our present advanced state of geographical knowledge. Before Columbus discovered America, —or rather, before the first complete voyage round the Earth,—how could it be known to what extent the ocean spread itself? This, indeed, put the matter beyond doubt: navigators, by continually sailing forward in the same direction, found that they at length returned to the place whence they set out; and *this* it is which affords the only direct and practical proof of our Earth being a round body.

Is it not another proof, inquired Eugenia, the circumstance of our perceiving the top of a vessel at sea *before* her hull, when she approaches us; and *after* her hull has disappeared, when she goes from us? How can this be explained, unless by the Earth being a globe?

I myself have perceived, added Isabel, when I stood upon the sea-shore, an evident *bend*, or curved appearance, which the surface of the waters had, at a great distance.

This is, indubitably, a proof, and a very strong one, so far as it goes, replied Franklyn. But you will recollect that it extends no farther than the sphere of the spectator's observation. The ancients themselves did not fail to draw, from so obvious a fact, the same inference, namely, that the *known part* of the Earth was globular; which was a theory held by several of the more enlightened. Not being acquainted, however, with more than half the Earth, that half alone was thought to be globular,—or, at least, proved to be so. Of the shape or dimensions of the remainder, they knew nothing. We, to be sure, who are able to make the same observation from different points both in the Old and New Worlds, as they are called, derive from thence a very strong argument, if it may not be dignified with the name of a proof, that the Earth is curved or spherical.

There are other proofs, too, subjoined Franklyn, which you may wish to learn, as "making assurance doubly sure," on such an interesting point. For example: in an eclipse of the Moon, which is occasioned by the Earth coming between her and the Sun, into such a position that the Earth's shadow is projected on the *Moon*'s orb; whenever this phenomenon takes place, the boundary of the Earth's shadow, seen on the Moon, always appears circular. Now, if the Earth itself were not globular, the boundary of its shadow would, in all probability, be sometimes of a different form from that of a circle.

Again: it is found that, by travelling northwards, or towards the pole-star, this luminary appears to rise higher and higher upon the sky. Nay more, that its elevation is exactly in proportion to the space travelled northwards. Thus, at Quito, a town nearly upon the Line, in South America, the pole-star seems to be on a *level with the ground:* that is, on the spectator's horizon itself, so as to be hardly visible. At the island of Trinidad, which is somewhat more northerly than Quito, the pole-star is elevated considerably above the spectator's horizon. At the island of Owhyee, which is about *twice* as far north of Quito as Trinidad is, the pole-star is elevated above the horizon *twice* as much as it was at Trinidad. At Grand Cairo, which is *thrice* as far north of Quito as Trinidad is, the pole-star is elevated above the horizon *thrice* as much as it was at Trinidad. At Madrid, Plymouth, the Shetland Isles, Scoresby's Sound in Greenland, and the North Cape of Spitzbergen, which places are, respectively, *four*, *five*, *six*, *seven* and *eight*, times as far north of Quito, as Trinidad is, the pole-star is elevated above the respective horizons, *four*, *five*, *six*, *seven*, and *eight* times as much as it was at Trinidad. And this is true of *all* the intermediate places between those I have mentioned: if we proceed northwards from *any* spot on the earth to *any* particular distance, and then to *double*, *treble*, &c. that distance, the elevation of the pole-star will be increased *twice*, *thrice*, &c. as much at the *second*, *third*, &c. distance, as it was increased by travelling from the chosen spot to the *first* place. Now, this phenomenon is an indirect proof of the Earth's sphericity.

How is that, Franklyn? demanded the Colonel whilst all the rest looked somewhat puzzled. I will show you, by help of a figure on the gravel, replied Franklyn, as Thales, one of the Seven Wise Men (not that I class myself with them as an *eighth*, continued he smiling), and the Father of Science, is said to have taught his pupils Geometry by the help of figures drawn upon the sands of the shore, while they walked together in philosophical conversation. You know what the *horizon* is?

Yes, answered Eugenia; the circular boundary in which the sky seems to meet the earth.

Very good! said Franklyn. The word being derived from *horizōn*, bounding, inasmuch as it bounds our view. I could hardly give you a better definition of it myself, without recourse to mathematics. You will recollect, however, that this is called the *celestial* horizon, being supposed to lie upon the concave surface of the heavens. Now, if the place on which we stand were such that nothing intervened all around us to prevent a *plane*, or flat surface, being stretched from it to meet the sky, would not this cut the sky exactly in the celestial horizon?

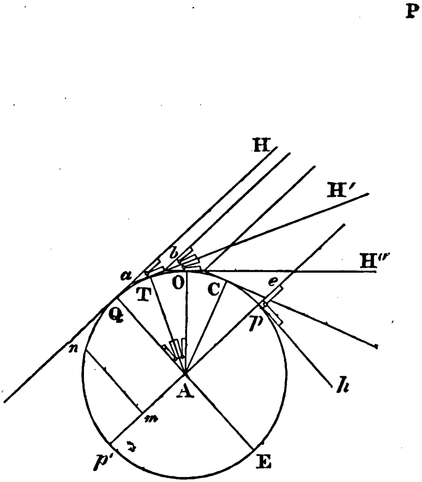
Not *exactly*, said Isabel; for our eyes being so far above the ground, we should see a little *below* where the level of the ground would cut the sky.

Spirit of Hudibras! a most critical distinction! cried Franklyn; and repeated from Butler's inimitable poem:

> "He was in logic a great critic,
> Profoundly skilled in analytic;
> He could distinguish and divide
> A hair, 'twixt south and south-west side!"

As you do, said he to Isabel, between Eugenia's horizon and mine: for, placed as we are at such a distance from the sky, there is not "a hair" difference between them. However, the imaginary line in which a perfectly flat surface, touching the earth where a spectator stands, and reaching to the skies, would cut them, *is* the *celestial horizon;* and the said plane is called the *plane of the horizon*. Remember that, for other purposes besides the present.

Now, gentles! attend. Let us *suppose* the Earth to be round, and that the circle I now draw is one of the flat faces made by slicing the Earth through its middle. Let A be the centre of the circle, Q the place of Quito on the Line; and let a traveller be conceived to proceed northwards from Q to T, the distance of Trinidad from the Line, thence



to O, the distance of Owhyee from the Line, and thence successively to C, &c. the respective distances of Cairo, &c. from the Line. Let QH, TH′, CH″, be straight lines just touching the circle at Q, T, O. At Q he sees P the pole-star in his horizon QH; that is, at Quito the pole-star has *no elevation* or *altitude* in the heavens. And if he walked on this line QH to *a*, still the pole-star would be in his horizon. But at *a* he comes upon the line *a* H′, that is, upon the horizon of T or Trinidad; and as he still sees P, the pole-star, in the same direction *a* P, it is now elevated above the new horizon *a* H′ by the angle P *a* H′. In like manner, if he walked forward on this line *a* H′, till he came to *b*, the pole-star would have the same elevation or altitude. But at b he comes upon the line $b\ H''$; that is, upon the horizon of O, or Owhyee; and the pole-star is now elevated above the horizon $b\ H''$ by the angle $P\ b\ H''$. Here we see then, that, *on the supposition* of the Earth being round, the elevation of the pole-star *would* be continually increased by travelling northwards, just as in matter of fact it is.

But, further: You shall see that, on the above supposition, the elevation of the pole-star would be not only increased, but increased exactly *in the same degree* as in matter of fact it is. For, as Owhyee is double the distance of Trinidad from the Line, therefore, if we have marked the places T and O correctly, the arch OQ will be double the arch TQ. Now, I open the sides of this carpenter's rule until it fits exactly into the angle $H\ a\ H'$. Removing it without alteration to the angles $P\ b\ H'$, $H'\ b\ H''$, successively, I see that it fits these exactly likewise; and therefore these three angles must be equal; and therefore the whole angle $P\ b\ H''$ must be double of the angle $H\ a\ H'$. In other words, on the supposition of the Earth being round, the elevation of the pole-star above the horizon $b\ H''$ of Owhyee would be double its elevation above the horizon $a\ H'$ of Trinidad, just as in matter of fact it is. By a similar process, it is evident that we might show the elevation of the pole-star above the horizon of C, or Cairo, to be thrice its elevation above the horizon of T; and so on for all the other places. Consequently, as, on the *supposition* of the Earth being round, the very same phenomena *would* be observed, which have *actually* been observed, we are entitled to conclude that the Earth *is* round.

I perceive the force of this argument, said the Colonel; but, as you yourself hinted, it is not so *direct* or incontrovertible as the first proof you brought forward.

I should hardly have troubled either you or myself with it, replied Franklyn, though I think it trong enough to be alone decisive of the question, —but for its great utility in *other* particulars. Let us see, for example, what we can deduce from it, beside the important fact of the Earth's globularity. Previous to this, however, I should wish you to understand, that the phenomenon we have just been concerned with is more accurately true of the *pole* itself, than of the pole-*star:* I made use of the latter, first, because it is so near the pole; secondly, and chiefly, because I wished you to have a distinct *image* before your minds, in the shape of a star. This being explained, we proceed with our deductions.

When I spoke of travelling *northwards* on the circle QTOC, of course I meant that the edge of that circle should be directed exactly towards the pole; or, in other words, that, if the plane of the circle here spread out beyond its terrestrial edge until it reached the skies, this plane would *pass* *through* the pole. Now, if Q be the place where the pole is in the horizon, and if we travel directly northwards to any other place T, we shall find that the elevation of the pole at T is equal to the angle spanned by TQ at the centre of the earth A. For, removing the carpenter's rule, without alteration, from the angle H *a* H′ to the angle QAT, you perceive that it fits into the latter exactly. In the same manner we shall find that the elevation of the pole at the place O, namely, the angle P *b* H″, is equal to the angle OAQ spanned by OQ at A. This is true for *all* places on the circle, as well as T and O. For instance, if we travelled so far northwards, to the place *p*, that the angle at the centre A required the sides of our carpenter's rule to be set *upright* on each other, in order to fill the angle; at this place *p*, the instrument with its sides thus upright, or *perpendicular*, as it is called, to each other, would exactly fit into the angle of elevation, *eph*, as you perceive. Hence we conclude, that if a man stood upright at *p*, like the side *pe*, the pole would appear directly over his head, in the direction *p e*.

How can that be, asked Reginald, when capital P is the pole?

Because capital P, or the pole, answered Franklyn, must be imagined so very distant, that all the lines QH, *b* P, *p e*, will have the same direction. For I have already shown the Earth to be so indefinitely small, with regard to its distance from the pole, that all lines from it, directed thither, must be considered as drawn from a mere point, and having no inclination to each other whatsoever.

Well; the pole P being exactly over p, if a straight line be conceived to pass from A, the Earth's centre, through p, and to be lengthened sufficiently, it will pass through the pole P. And, in like manner, if this line p A be conceived to pass in the opposite direction through p, and to be lengthened sufficiently, it will pass through the *south* pole P′; because P and P′ are exactly opposite to each other in the concave surface of the sky. If then we imagine this concave surface to turn upon the whole line PP′, as upon an axle, the line PP′ may be called the *Celestial Axis*. Likewise, from their similarity of position in the terrestrial sphere, p and p' are called the *North* and *South Terrestrial Poles*, whilst the imaginary line joining *these* poles is called the *terrestrial axis*.

Does not the Earth turn upon this axis? inquired Isabel.

First, let us conclude with the *appearances*, and then we shall explain the *realities*, said Franklyn, and continued his last subject.

It is evident that the axis $p\,p'$ divides the circle p Q p' E p into two equal parts, namely, p Q p', and p' E p, each of which is called a *semi-circle* (properly *hemi*-circle, from *hemi*, the Greek for half); also the line $p\,p'$ is called a *diameter* of the circle (from the Greek words *dia*, through, and *metron*, measure, because it measures through the circle); and each of the equal portions A p, A p', being half the diameter, is called a *radius* (the Latin for ray, as it seems to emanate from the centre A like a ray of light from a luminous point). All which particulars I humbly desire your excuse for specifying, as you are no doubt already acquainted with them. But, to proceed:

The carpenter's rule, having its sides perpendicular to each other, and being placed as we last supposed it, so as to fill the angle p AQ, if the line QA be continued through A to E, then QE will not only be a new diameter (as it passes through the centre A), and thus have a semicircle at each side of it; but it will divide the first pair of semicircles, each into two *equal* parts, so that the whole circle will be now divided into *four* equal parts; which is manifest enough of itself, but may be proved by drawing a paper circle, with two diameters upright on each other, like those on the gravel, and then cutting it along those diameters: the four parts, thus formed, will be found exactly equal in all respects, if laid one upon another. Now, each of these four equal portions I spoke of, is called a *quadrant* of the circle (from the Latin word *quatuor*, four); and observe, also, that, as the curve-line *boundary* of the circle is called the *circumference*, each of *its* four equal portions is called a *quadrant* of the *circumference*. Q, then, is distant from the terrestrial pole *p*, by a whole quadrant of the circumference, QTOC*p*; and also from the *south* pole *p'*, by the same quantity. Hence, if we conceive the whole circle twirled once about the axis *pp'*, as you would twirl a dollar between your finger and thumb, the point Q, running along the surface of the Earth, would trace out on it another circle, distant in all its points from each pole *p* and *p'*, by a quadrant. Consequently, the whole surface of the terrestrial sphere would be divided into two equal portions by this circular line; and the terrestrial sphere *itself* would be divided, by the sweeping line QA, into two equal *solid* portions, called *hemi-spheres;* that is, half-spheres.—Do you understand this?

All answered,—"Perfectly! perfectly!"

If you understood a little GEOMETRY, I could explain it on a much simpler principle, said Franklyn; that not being the case, I am obliged to take a somewhat roundabout method.—Well: the aforementioned circular line is that remarkable one, called, by pre-eminence, *the Line*, which you must have so often heard of; and because at all places on it the days and nights are equal, it is also called the *Equator*, or sometimes the *Equinoctial* (from *æquus*, equal, and *nox*, night).

And is not the circle *p*Q*p'*E called the *Meridian?* asked Mrs. St. George.

Yes, said Franklyn; it is *the* meridian of any place, as T, through which it passes; but *every* circle, as well as this, which is made by slicing the Earth through its axis, is *a* meridian. It is so called from the Greek *merizo*, to divide; because, when the sun is exactly over the meridian of any place, it is then *mid-day*, or noon, at that place. Recollect also, that, as the angle QAT, spanned by the arch of the meridian QT, measures the breadth, or *latitude*, of the place T from the equator, this angle is called the *latitude of the place* T.

Now, let us see what our first deduction resolves itself into, after the foregoing explication of so many astronomical terms. Why, that *the elevation or altitude of the celestial pole at any place, is equal to the latitude of that place*. Thus, at T, the altitude of the celestial pole is H *a* H′, the latitude is QAT, and these angles were shown to be equal.

I thought, said Eugenia, with some hesitation, that latitude was always measured on the *surface* of the earth, and not by an angle at its centre, as you have told us. Thus *I* would have said, that the arch QT *itself*, was the latitude of the place T.

It is altogether indifferent which we choose, replied Franklyn, as the arch is always proportional to the angle at the centre which it spans. For example, if, as we have already supposed, the point O be twice as far from the equator as the point T, or if the point O have double the latitude of the point T in *your* sense of the word, it will have likewise double that latitude in *mine*. For, applying the carpenter's rule, so as to measure the width of the angle QAT, you will find, by applying it to the angle TAO, that it will exactly fit into this angle likewise. Your observation, however, reminds me to explain a division of the circle which is much used in Astronomy: You know what the *brazen meridian* of a common globe is?

Yes; the brass circle which surrounds the globe, and is marked on its side by a number of straight lines all pointing to the centre of the globe *.

Just so; and, if the globe be accurately made, all these lines would, if lengthened inwards, meet exactly in the centre of the globe. You have, I dare say, likewise observed, that all the little arches, between each neighbouring pair of lines, are equal to each other; and that in each quadrant there are 90 of them, every 10 of which are numbered thus:—10, 20, 30, 40, 50, 60, 70, 80, 90; beginning from the equator and ending at the pole. Now, each of these little arches is called a *degree;* of which there must be *four* times *ninety*, or 360, in the whole circumference. Likewise, if the aforesaid lines of division were continued inwards to the centre, there would be formed 360 little angles at that point, all equal to each other (as I have just exemplified, or as you may yourselves demonstrate, if you choose to be at the trouble of dividing the arch of a paper quadrant into 90 equal parts, and

* See the Engraving at the head of this Chapter.

then cutting from the points of division to the centre in straight lines; for you will find that all the triangular pieces of paper so formed, will, if laid one upon another, have all their *peaks* exactly equal, and, indeed, be in every respect equal to each other).

It is plain enough, said the Colonel, without such a watch-paper operation; there must be 360 equal angles at the centre, formed as you describe, 90 for each quadrant of the circle.

Well, then, continued Franklyn, such being the case, if a point on the globe be brought under the brazen meridian, and if it appear to be a certain number of the little arches distant from the equator, its *radius* will also be that same number of corresponding little angles distant from a radius through the point where this meridian cuts the equator. Thus, if T be the point, and if just over it on the brazen meridian appears the number 10; signifying that it is distant 10 little arches from Q on the equator,—then also its radius TA will be 10 little corresponding angles distant from the radius QA. You see from this, that it is perfectly indifferent whether we reckon the latitude of T on the surface by little arches, or at the centre by little corresponding angles. Both the arches and the angles may be designated by the common name *degrees*, and we may use whichever is most convenient to the purpose. London, for instance, has $50\frac{1}{2}$ *meridional* degrees of latitude, and just the same number of *angular* degrees. Upon this subject, I have only to add, that if two circles, lying in the same plane, have the same centre, and that the inner one be divided by rays into 360 degrees, the outer one will be also divided into 360 equal parts or degrees, merely by lengthening the rays of the former to meet the circumference of the latter. The degrees of the outer circle will, of course, be individually larger than those of the inner; but exactly the same *number* of them will correspond to, or span, or measure, the same angle at the centre. Thus, if 10 degrees of the latter span the angle at the centre, 10 degrees of the former will exactly span the same angle. Consequently, if there be *any* two circles, whether in the same plane or not, both of which are divided into 360 degrees, and if we take, on the circumference of both, arches containing the same *number* of degrees, these arches will correspond to, span, or measure, angles at both centres of exactly the same width. Thus, if we take an arch of 10 degrees on one circumference, the angle it spans at the centre of that circle will be equal to the angle spanned at the centre of the other by an arch of 10 degrees taken on *its* circumference. And *vice versâ*, if we take two equal angles at the centres of the two circles, these angles will correspond to, or be spanned or measured by, two arches of the circumferences, which, however different in length, shall contain exactly the same *number* of degrees.

Yes, said the Colonel; but the degrees of the larger circle will be greater than those of the smaller.

How very useful, observed Eugenia, this principle must be, not only in Astronomy, but in various other subjects of contemplation!

You shall soon have a practical proof of the truth you have asserted, replied Franklyn; for by means of it we will now proceed to calculate the size of the Earth.

Of the Earth! cried Isabel: can that be done by this, or any other means, with the least degree of certainty?

You shall see, answered Franklyn deliberately. —We have shown that the elevation of the celestial pole above the horizon of any place, is equal to the latitude of that place. If then we travel directly northwards from any place, where the elevation of the pole is, say 20 degrees, to a place where the elevation of the pole is 21 degrees,—will not the latitude of the second place be one degree more than the latitude of the first?

Certainly.

That is to say, continued Franklyn, if rays be drawn from both places to the centre of the Earth, these rays will form at the centre *one angular degree of latitude;* and, therefore, the arch of the meridian which spans this angle will be *one meridional degree* of latitude?

Certainly.

Very well. Now, it is found that, in travelling that arch, $69\frac{1}{2}$ British miles are gone over; wherefore, $69\frac{1}{2}$ British miles is the length of a meridional degree. In order to obtain the length of the whole meridian; or, in other words, the whole circumference of the Earth, which consists of 360 such degrees, what more have we to do than to multiply $69\frac{1}{2}$ by 360, which will give 25,000 British miles nearly.

This then is the circumference of the Earth?

Pretty nearly, on the supposition that the Earth is a *perfect sphere*, replied Franklyn. And such being the length of the Earth's circumference, Reginald, I am sure, can tell us the length of its diameter.

I? said Reginald, with a look of suspicion. With what a grave face you can banter one, Franklyn! How should I be able to calculate the Earth's diameter?

Why, have not you studied MATHEMATICS? demanded Franklyn.

Yes, I have read the books you gave me, with my tutor.

And, pray, of what use has your reading been, if you can turn it to no account? said Franklyn rather severely. Can you recollect no principle which seems to bear on the present question?

I recollect, answered the boy after long consideration, that there is some proportion between the circumference and diameter of a circle, but I forget what it is.

Nearly that of *three and a seventh* to *one;* in other words, the circumference is nearly thrice the diameter, together with a seventh of the diameter. Now, you can tell me what the diameter of the Earth is, nearly; indeed, it is specifically mentioned in one of the books you allude to.

The circumference of the Earth being 25,000 miles, its diameter must be about 8000 miles; because three times 8000, and a seventh of 8000 (which is rather more than 1000) make up together 25,000 *.

You are to recollect, however, said Franklyn, that our calculations and conclusions have been made on the hypothesis of the Earth being a "perfect sphere." But this is not the case. It has been found, by actual measurements, that near the terrestrial poles, a greater space must be gone over, in order to elevate the celestial pole one degree, than near the equator. This shows that the traveller does not ascend so steep an arch at the former as at the latter; in short, that the Earth must be *flatter* about the poles than at the equator; and that its shape must be rather that of an *orange* than a sphere. Experiment likewise

* See DARLEY'S GEOMETRICAL COMPANION, page 91, and TRIGONOMETRY, ARTICLE 31, for Mathematical Demonstrations on this subject.

shows, that the same body is heavier near the poles, than near the equator; which also proves the orange-like form of the Earth.

I do not immediately perceive in what manner, said Eugenia: nor, indeed, can I imagine how the *weight* of any particular body should be drawn into an argument for the *shape* of another. There appears to be no sort of connexion between the two things.

And, therefore, observed Franklyn, the more will you be astonished at the profound sagacity of NEWTON, who could, from such an apparently trivial and remote experiment, actually deduce the comparative lengths of the polar and the equatorial diameters, and, in such an immense, rugged body as the Earth, discover, by the mere force of mathematical reasoning, that the latter was greater than the former, by so nice a quantity as about 26 miles. Well, indeed, might the epigram be written—

> "Nature, and Nature's laws, lay hid in night:
> God said, "Let Newton be!" and all was light!"

But I see you are not inclined to take any of my assertions as oracles; which is really a great inconvenience. Having been rash enough to mention an experiment, I jumped boldly to a conclusion, in hope that you would all have jumped along with me—when, behold! you stop short, with a perplexing —"I don't understand that!" thereby putting me to my wits' end for an explanation.

And can you not explain it, indeed? said Eugenia doubtfully.

Franklyn made no direct answer, but, drawing his forefinger and thumb from the bridge of his nose down about the corners of his mouth, and so on to meet at the point of his chin, like a person who wishes to smooth his features into an air of great importance, he quoted, appropriately enough, the Hudibrastic description:

> "At this deep Sidrophel lookèd wise,
> And, staring round with owl-like eyes,
> He put his face into a posture
> Of sapience, and began to bluster;
> For, having three times shook his head,
> To stir his wit up, thus he said"—

I'll tell you all about it to-morrow!

Go your ways for another *Sidrophel!* exclaimed Isabella, as he made his escape—though I don't know exactly who he was, added she when the fugitive was out of hearing.

The *conjuror* in Hudibras, said her Father, who thus prepared himself to answer the Knight's formidable query—Why a *sign-painter* never draws the *full-moon*, but always the *half?*

Our Sidrophel, quietly observed Mr. St. George, will, I dare say, have better success. But he thinks we have had as much information to-night, as should be communicated at a time.

With this remark, the party walked up the broad avenue, that led to a lattice-door opening into the parlour; at the steps of which they met Franklyn, who darted out from one of the side alleys, and arrested them, just as they were about to stoop under the festoons of ivy, honeysuckle, and virgin's-bower, which hung in clustering drapery from the eave. All turned about, as they saw him look steadfastly upwards, while he uttered some lines, containing an allusion which they could not misunderstand:

"Thus, at their shady lodge arrived, *all* stood,
All turned, and under open sky adored
The God that made both sky, air, earth, and heaven,
Which they beheld, the moon's resplendent globe,
And starry pole!"

A silence of some moments ensued, as the reciter's voice fell. How it was employed by each, no one but themselves can positively declare. Few persons, however, let their creed be what it may, contemplate the beauty, and the majesty, and the splendour, of a moonlight scene, without some deep and powerful emotions, at least, of *natural* religion; without drawing from thence a most persuasive testimony of the power, and the wisdom, and the glory of God. "I had rather," says the immortal Bacon,—"I had rather believe all the fables in the Legend, and the Talmud, and the Alcoran, than that this *Universal Frame* is without a Mind!"

EVENING THIRD.

REGINALD, said Franklyn to the Boy who was employed in jerking pebbles out of a sling,—tie up a pretty large stone in the loop of your sling, and then whirl it round your head.

Well, there it is whirling! said the Boy. How long am I to continue this exercise?

What sensation do you feel in your sling-hand?

Why, as if it was pulled very hard; as if the stone-end of the sling wanted to fly off from it.

Do you remember, said Franklyn turning to the rest of the Party who had stood at a respectful distance watching what they thought a childish experiment,—do you remember, in our last night's conversation, the "sweeping line Q A" that traced out the equator?

Yes, the figure you then drew remains unobliterated on the gravel.

Now, if the Earth really whirled round its axis, demanded Franklyn, would not this sweeping line Q A resemble the sling your Brother whirls round his head? would not a *stone* at the point Q have a tendency to fly off from the centre A, just as the stone in the loop of the sling has a tendency to fly off from the hand, which is the centre of a circle, whose radius is the length of the sling?

Yes, we have no doubt that it would do so.

Then why does it *not* fly off?

Because of its *weight*, replied the Colonel.

Exactly. If the Earth were at rest, the stone at Q, as likewise all other bodies, would have a tendency *towards* the centre A, or would, if raised sensibly, press in that direction; which tendency or pressure is called the *weight* of the stone. But when the Earth began to revolve, this tendency or pressure would be diminished by the *opposite* tendency to fly off, which that motion would communicate as we have seen by our experiment. In other words, the *weight* of the stone would be diminished by the rotation of the Earth.

This is very plain.

Nor is it less so, added Franklyn, that the weight of the stone would be diminished in proportion to the velocity with which it revolved; for the motion being greater, would communicate a greater tendency to fly off, and therefore counteract the tendency to the centre in a greater degree. Thus, if Eugenia will take the sling, and whirl it round her head, first slowly, and then with gradual rapidity, she will find that the tendency to fly off will gradually increase, till at length the stone will almost run away with her hand.

I am excessively obliged to you, Sir! returned Eugenia, for your kind desire to make me your demonstrator; but I have no wish to lose a hand in the service.

You would prefer *giving* it away in another service, observed our Academican gravely, and I can only hope, that there may be no tendency "to fly off" without it, while you think you are the centre of attraction. But, jesting apart: you perceive that if *m n** were another "sweeping line," which, as the Earth revolved, traced with its end *n*, another but a smaller circle,—you perceive that the tendency of the stone at Q to fly off, would be greater than that of a similar stone at *n* to fly off.

I see that it would, replied the Colonel, and yet I cannot exactly tell why.

Because the stones at Q and *n* would revolve

* See figure, page 32.

with the Earth, being supposed on the same meridian, in precisely the same time, but the former would revolve in a larger circle than the latter. In other words, the stone at Q would move with *greater velocity* than the stone at *n;* just as we say that a horse which trots ten miles in an hour, moves with greater velocity than a horse which trots eight miles in an hour. But we have shown that the greater the velocity, the greater the tendency to fly off. Consequently, the tendency of the stone at Q to fly off, would be greater than that of the stone at *n* to fly off; or, as the immediate result of this, the *weight* of the former stone would be more diminished than that of the latter.

Therefore, in short, observed Mrs. St. George, the same stone would be lighter at the equator, than at any place to the north or south of it.

Just so. And at the poles it would be heaviest of all, rejoined Franklyn; inasmuch as there the circle in which it revolved would be but a mere point, so that its velocity, as compared to the velocity on the equator, would be almost nothing, and therefore its comparative tendency to fly off almost nothing likewise.

Well, this is all very interesting, said Eugenia, and throws a clear light over many things, which, as yet, I saw obscurely. But what connexion has it with the *shape* of the Earth?

A very close one. All bodies, as we have seen, being lightest at the equator, the particles of sea-water are there lighter than in the neighbourhood of the poles. Consequently, a greater number of them would be collected at the equator than near the poles, in order that, on the whole, a balance might ensue; so that, unless the *land* at the equator were higher than near the poles, the equatorial regions would be *overflowed*. But we see that they are *not* overflowed, and therefore we conclude that the land near the equator is higher than near the poles; or, in other words, that the Earth is not spherical, but, as I said, orange-like in its figure.

Strange! exclaimed Eugenia, to what a remote and important conclusion that trifling experiment has led us!—What a wonderful being was Newton!

So wonderful, rejoined Franklyn, that a celebrated French philosopher, the Marquis De L'Hopital, after the perusal of his great work, the PRINCIPIA, was in some doubt whether he were a human being; and gravely inquired of an English gentleman, "whether Newton *ate* or *drank* like another man." But you are not to understand, that the mode of reasoning which I have pursued was Newton's. His was far more scientifical and elaborate; indeed, totally distinct, though built on the same primary foundation, that of the weights of bodies. Your unacquaintance with the principles of mathematics restricts me to giving you merely a popular, and, as it were, *side view* of the matter, such that any one habituated to scientifical accuracy of demonstration would justly think deficient. This, however, is your fault, not mine.

Is not that "tendency to fly off," which you have been speaking of, generally denominated the *centrifugal force?* asked the Colonel.

Yes, Sir; from the Latin, or rather from the Greek words *centrum* a centre, and *fugo* to drive.

But, Franklyn, said Reginald whose head the centrifugal force had somewhat addled, if the Earth really does whirl round and round in that manner, how are we able to keep our feet?

By means of the *weight* of our bodies; or, as I before explained this term, the tendency *towards* the Earth's centre, which is much greater than the tendency from it, occasioned by the centrifugal force.

I cannot believe that we are twirling about in that manner! said the Boy. I don't feel myself moving.

Have you ever made a sea-voyage?

Yes, said Reginald; I sailed to France and back again.

Perhaps you were on deck all the time?

No; I was very ill, and lay in my hammock.

Very ill for yourself, but very well for me. While you lay in your cabin, did you perceive the vessel to move? said Franklyn.

Yes, it appeared to shake and joggle.

Pooh! I mean, did you perceive it to move *forward?*

Why, no, said Reginald; and I could hardly get myself to believe that we were moving on an inch, though the Steward told me we went at the rate of ten knots an hour.

Just as you can hardly get yourself to believe that you are moving on, now, while the Earth carries you forward, no less certainly than your vessel did upon that occasion.

Ay, but, said Reginald, I had only to go upon deck, and then I *saw* that the ship did really move.

How did you *see* it, let me ask you?

Why, I saw the waves going past us in the opposite direction; and I saw the lands of one shore receding, and of the other approaching.

That is, said Franklyn, *appearing* to do so; from whence you justly concluded, that as the lands were fixed, it was the vessel which moved. Now why might you not conclude in the same manner, that the Earth is moving although you don't perceive its motion?

I might do so, to be sure, if there were any lands outside of it, which I knew to be fixed.

What do you call those stars? said Franklyn pointing over head. Will not they satisfy you? Whether they are "lands" or no, is immaterial; they are *objects*, and you know them to be fixed.

I know them to be fixed, with regard, as you said, *to each other*, said the Boy acutely, but I do not know them to be absolutely fixed in the same places, as lands are on the Earth. Indeed, they manifestly are *not* fixed in the sky, for we see them whirl about the pole every night; unless, it may be, that both they and the sky whirl about, all at once and together.

Very well. But whether is it more natural, more simple, more credible, that the countless multitude of bodies we now behold, as they are, if we include all which telescopes discover, many of them infinitely greater than the Earth, few of them smaller, should perform the whole circuit of the heavens in twenty-four hours,—or that the Earth should, in the same time, merely revolve once on her axis?—For it is plain, that on the latter supposition, the stars, and planets, and moon, or the heavens themselves, would *appear* to move, just as they really would move on the former supposition.

That is true, said Reginald. But then, the stars seem so palpably to move, and the Earth feels so certainly to be at rest!

I have already, said Franklyn, answered the last part of your objection. As to the first: how often are we deceived respecting motion in external objects! Travelling inside a carriage, we think the trees and hedges, by the road-side, move past us in a direction opposite to that in which we are going. We, indeed, know that these objects are fixed, and therefore our judgment corrects the error of our sense. But, if we were in the cabin of a ship, and saw from its window a log, or cask, upon the water, at some distance, in apparent motion, I would defy any of us to tell whether that motion was in the said object, or in our own vessel, or in both,—that is to say, unless we had some other ground on which to form our opinion. In like manner, when from a nook in this terrestrial vessel, floating amidst surrounding ether, we behold the heavens in apparent motion, it is impossible for us to tell, whether that motion is in the heavens or in our vessel,—unless we have some other ground on which to form our opinion.

Then, in fact, observed the Colonel, however *probable* it may be that the Earth revolves on its axis, instead of the whole system of heavenly bodies, inasmuch as the former is, as you say, the most natural and simple hypothesis,—yet we cannot positively assert, that the motion is in either one or the other.

Yes, we may positively assert, that it is in the Earth, replied Franklyn. Many proofs of this might be adduced, but the only one I recollect, which would not involve deeper scientifical principles than you have yet fathomed, is the following. As it is an experiment of a practical nature, you will probably feel more convinced by it than by a thousand mathematical arguments. First, then, in what direction is the apparent motion of the stars?

From East to West, answered Eugenia.

Do you know, said Reginald, that I never can be sure which is the East and which is the West?

Turn your face to the North Pole, said Franklyn placing Reginald as he described. Now the East is on your *right*, and the West on your *left*. That is the way you will always be able to distinguish these cardinal points, which, remember, are in the *horizon*; and the points exactly between them, both North and South, are the North and South cardinal points, also in the horizon. "Cardinal" means principal, or *hinge*-points, from the Latin word *cardo* a hinge. The four cardinal points divide the horizontal circle into four *quadrants*.

But suppose it was day-time, when there was no Plough visible, by which I could find out the pole? said Reginald.

If you have a magnetic needle, its two ends point respectively North and South, you can hardly fail to distinguish which is which. But as this instrument is, in the first place, not always at hand, and, in the second, does not lie exactly North and South, a better method is to observe the shadow of an upright slender object (such as the trunk of a straight tree) at the moment of *noon*; this shadow will then point directly to the North.

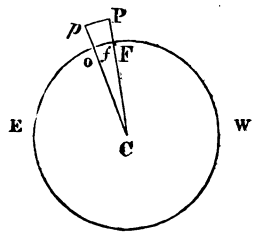
How pleasant it is to know that! exclaimed Isabel. For my part, I have never been able to tell whether a mountain lay to the North or South; whether the road I travelled ran East or West. Now I shall find no difficulty.

True; but you must always manage to carry a clock with you, observed Franklyn; unless your watch goes better than Ladies' watches do in general. However, as we were saying: the apparent motion of the stars is from East to West.

Consequently, if that apparent motion be due to a real motion of the Earth on its axis, this real motion must be from *West* to *East*. By this means, the stars will be successively uncovered, and appear to move over the heavens in an opposite direction. Well! if the Earth do revolve from West to East, of course, a body let fall from any considerable perpendicular height, as from the top of a lofty tower, for instance, will not drop exactly at the foot of the perpendicular (as it would if the Earth were at rest), but a little to the *eastward* of the perpendicular.

Why should that be so?

Inasmuch as, replied Franklyn drawing a figure, if this circle were the equator, F P a perpendicular height upon it, C the centre of the Earth; then while the Earth revolved from the



West, W, towards the East, E, so as to bring the perpendicular, F P, into the position, *f p*, in that time the top P would have moved through the arch

P p, and the foot F through the arch Ff. But the arch P p is evidently greater than the arch Ff; or, in other words, the top P moves *faster* than the foot F. Now, if a body were let fall from P, as it would leave P, with the same degree of motion eastward, as P had; and as nothing, except the light resistance of the air, occurs to retard this its motion, it likewise would, of course, move faster than F, during the whole time of its descent. Consequently, when it reached the ground, as at o, it would be farther to the east than the foot, f, of the perpendicular. But it is found, by experiment, that this result actually takes place; and hence, we conclude, that the Earth must revolve from West to East, in order to produce this result.

When, or where, was that experiment tried?

At Bologna, Viviers, and Hamburgh. At the latter place, a body was let fall from a height of 250 feet, and the arch $f\,o$, or the distance between the foot of the tower, when the body reached the ground, and the body itself, when there, was found to be very nearly what it ought to be, on the supposition of the earth so revolving. The slight difference was occasioned by the resistance of the air, or those errors unavoidable in so nice an experiment.

At all events, observed Reginald, the Earth must revolve very slowly, or we should lose our breath in passing through the air.

My dear Boy, said Franklyn, the Earth carries the air along with it, just as it carries the ocean; for the air is only a kind of thin and respirable fluid, covering the whole earth, as water covers a part. Air is a material substance, though of a very light nature; and is to us pretty nearly what the sea is to fishes. You would not say there was any danger of a fish "losing its breath," because of the Earth's revolution on its axis; it is not carried through the water an iota faster than it chooses to swim, on that account, but the water is carried *with it*. In like manner the air is carried *with us;* and we only move through it as fast as we choose to walk, ride, sail, &c. As to the time which the Earth takes to revolve once upon its axis, that must of course be exactly equal to the time which any fixed star apparently takes to perform an entire revolution of the heavens. I will show you how this period is to be ascertained:

Choose any particular fixed star, and pointing a telescope at it, mark the instant by a good clock. Then, if the telescope be rendered stationary, observe next night when the same star is visible through it. The interval of these two observations will be the period in which the star has completed its apparent revolution; in other words, it will be the time of the Earth's revolution on its axis.

Might not different stars give different results? inquired the Colonel.

No, certainly; inasmuch as they are fixed with regard to each other, and therefore must all appear to make a complete revolution in the same time. Whatever star you select, it will be found that the time of a complete revolution is always 23 hours 56 minutes, exactly.

And does the Earth revolve equally fast at all times? demanded somebody.

Yes, replied Franklyn, as the same telescope will evince: for direct it to what part of the star's apparent course you will, 23 hours 56 minutes, neither more nor less, will elapse before it is visible through the fixed telescope again. Or you may ascertain all these truths by a much simpler process than a regular observation with a telescope. Instead of that instrument, look along two perfectly upright poles set in the ground, till you catch a star just behind the furthermost: mark the instant as before, and repeat the observation next night, taking care that it is the *same star* you notice. This will answer quite as well as the telescope; especially if, instead of *poles*, which it is hard to set *exactly* upright, you make use of two lines with weights at their ends, called *plumb-lines*, or *plummets* (from *plumbum* lead, the weights being generally of this material). These lines, being suspended, will hang perpendicular to the horizon.

Did you not say that the Earth was 25,000 miles round? asked Eugenia.

Yes, about that.

If so, then, concluded our Female Philosopher, it must revolve at the rate of more than 1000 miles an hour, inasmuch as it completes a revolution of more than 24,000 miles in less than 24 hours. So that, although we appear to be standing perfectly still, we are in fact moving along with the Earth upwards of 1000 miles in an hour!

Not very far from it, returned Franklyn; but you are to recollect, that the terrestrial circle passing through *our* latitude, which is about 51 degrees and a half north, cannot be stated at much more than *half* 25,000 miles in length, because the circles of latitude evidently diminish from the equator towards the poles. Hence, although a person on the equator revolves at the rate of more than 1000 miles an hour, we revolve only at about the rate of 600 miles an hour.

Ten miles a minute: quite enough in all conscience! exclaimed the Colonel laughing.

About one half as quick as a cannon-ball, said Franklyn preserving the imperturbability of his muscles; no more. It is, however, I admit, not a little repugnant to common experience, that we should be moving so rapidly without the least consciousness of it; but always let us remember how fast we can drive before the wind, when shut up in the cabin of a vessel, and yet remain totally unconscious that we are moving onward at all. Such being the case, if the vessel were to drive still faster,—as fast as the Earth revolves,—we should have no perception whatever of the motion, but that she, not carrying her atmosphere with her, as the Earth does, would, as Reginald says, take our breath from us by the velocity with which she passed through it. This sensation alone would inform us of what was really the case, by incommoding us; but we have already seen that we cannot experience this telltale sensation while our advance is not resisted, but accompanied by the atmosphere.

Do all those planets, then, which you call so many Earths, revolve like the Earth? said Isabel.

Every one of them, as far as we are able to examine and judge, replied Franklyn. And from this circumstance we draw another argument in favour of the Earth's rotation; for the planets and Earth being in so many other respects similar bodies, and endued with similar properties, *analogy* obliges us to conclude them similar in this also.

But how is it known that they do revolve? inquired the Colonel.

By the apparent motion of *spots* on their faces or *discs*, as astronomers call them, from a fanciful resemblance to the *discus* or quoit, a round flat plate of metal, stone, or wood, which the Greeks and Romans used to bowl along the ground for sake of exercise. There are various other proofs of the fact, but at present we will be satisfied with understanding this one:

Schroeter, a celebrated German astronomer, discovered, by a series of telescopic observations, that certain spots appeared to move over the *disc* of the planet Venus in about 12 hours. This apparent motion of the spots he naturally attributed to a real motion of the planet about her axis; which latter motion was, therefore, twice as long as the former, inasmuch as the spots were invisible while on the *back* or other hemisphere of the planet. Hence he concluded, that the time of Venus's rotation was about equal to that of the Earth, or, more accurately, 23 hours 30 minutes. Dr. Herschel ascertained, in like manner, that the period of Saturn's rotation on his axis, or his *diurnal motion*, as it is called, was only about 10 hours and a quarter. The diurnal motion of Mars is nearly three quarters of an hour longer than that of the Earth; and the diurnal motion of Jupiter is nearly one quarter of an hour shorter than that of Saturn. In the other six planets, no spots have been discovered, or at least examined with sufficient nicety to warrant us in pronouncing the time of their rotation. I will only here add, that the motion of their spots shows that the former planets revolve from West to East; which is another analogical proof that the Earth does so too, as was asserted.

Here Reginald desired to know the names of all the Planets.

Franklyn enumerated them, scratching on the gravel with a pointed stick the symbols or characters by which they are often designated in Astrological and other works:

Mercury ☿	Pallas ⚴	Jupiter ♃
Venus ♀	Juno ⚵	Saturn ♄
Mars ♂	Vesta ⚶	Georgium Sidus ♅.
Ceres ⚳		

Of these, said Franklyn, but *five*, namely, Mercury, Venus, Mars, Jupiter and Saturn, were known to the Ancients. Ceres was discovered by Piazzi, at Palermo in Sicily, on the first of January, 1801; Pallas, March 28, 1802; and Vesta, March 29, 1807, by Dr. Olbers; Juno, September 1st, 1804, by Harding; the last three in Germany. Herschel discovered the remaining planet, which he named the Georgium Sidus, or *Georgian Star*, in honour of George III., March 13, 1781. On the continent, however, the Georgium Sidus is denominated in preference *Herschel*, or *Uranus*.

Is not the Moon an *eleventh* planet? said Reginald.

No, but the *Earth* is, replied Franklyn; inasmuch as it revolves, like the other ten, immediately round the Sun, without first revolving round any other body, as the Moon does round the Earth.

What! must we believe that we are moving round the Sun too! cried Reginald; and yet don't perceive that we move at all? This is too much!

Too much to explain and demonstrate this Evening, returned Franklyn, quietly. For as gentle Edmund Fairfax says—

"Now spreads the Night her spangled canopy,
And summons every restless soul to sleep,
On beds of tender grass the beasts do lie,
The fishes slumber in the silent deep;
Unheard is serpent's hiss and dragon's cry,
Birds leave to sing and Philomel to weep,
Only that noise Heaven's rolling circles kest
Sing lullaby to bring the world to rest."

Beautifully simple and poetical! exclaimed Eugenia. But I never heard the word *kest* before.

It is the past tense of the verb *to cast*, replied Franklyn; and here signifies to *emit*. The verse alludes to that sublime fancy which the Ancients indulged,—of the celestial bodies uttering in concert a mystic stream of sound, as they perpetually rolled, each in its several circle. This was the *Music of the Spheres*, which you have so often heard of; and it is one of those lovely dreams, for whose complete dissipation we have to thank Science, however ambiguously. The Poets, indeed, still cling to it fondly, as a belief in which they delight to persevere, notwithstanding their wilful credulity may be ridiculed by him who "sits down in the chair of the scorner." Thus Goethe sings, in his Faust, as elegantly translated by Lord Leveson Gower:

"The Sun his ancient hymn of wonder
Is pouring out to kindred spheres,
And still pursues in march of thunder
His preappointed course of years."

The Sun's "march of thunder" expresses the awful melody which is supposed to result from the mighty rushing of that sovereign sphere through the realms of space; and the other orbs have each their appropriate part to fill in the celestial chorus, that of Saturn being peculiarly deep, melancholy, and sonorous.

This just reminds me, said Isabel, of another question which I had to ask you respecting those lines you repeated from the Merchant of Venice:

> "There's not the smallest orb which thou behold'st,
> But in his motion like an angel sings."

I suppose that Shakspeare, as well as Fairfax, alludes to the Music of the Spheres in this passage.

He does so, replied Franklyn; and in the next verses would seem to give a reason, which was by no means superfluous, why we could not hear what we speak of so enthusiastically,—

> "But while this muddy vesture of decay
> Doth grossly close us in, we cannot hear it."

Though some interpret these lines differently. I have also met with a short Poem, entitled "The Fallen Star," in which a new theory upon this subject is put forth; namely, that the harmony of the Spheres is not produced by those bodies themselves, but by the Guardian Spirits who inhabit them. I must recite it as we walk up the avenue:

"A Star is gone! a Star is gone!
  There is a blank in Heaven!
One of the Cherub-quire has done
  His aery course this Even.

He sat upon the orb of fire,
  That hung for ages there,
And lent his music to the quire,
  That haunts the nightly air.

But when his thousand years were past,
  With a cherubic sigh,
He vanished with his car at last—
  For even Cherubs die!

Hear how his angel-brothers mourn,
  The minstrels of the spheres!
Each chiming sadly in his turn,
  And dropping splendid tears.

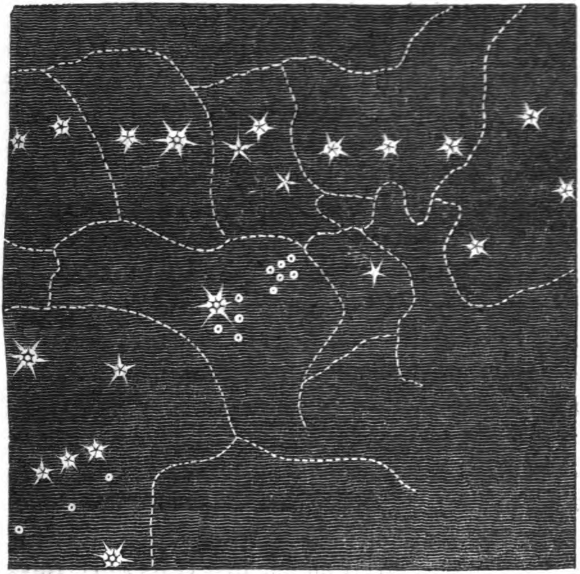
The planetary Sisters all
  Join in the fatal song,
And weep their hapless brother's fall,
  Who sang with them so long.

But deepest of the choral band,
  The lunar Spirit sings,
And with a bass according hand
  Sweeps all her sullen strings.

From the deep chambers of the dome,
  Where sleepless Uriel* lies,
His rude harmonic thunders come,
  Mingled with mighty sighs.

The thousand car-borne Cherubim,
  The wandering Eleven,
All join to chant the dirge of him
  Who fell just now from Heaven!"

* Uriel—the "regent of the sun."



EVENING FOURTH.

Hardly had our Astronomers entered the orchard, when Reginald stopped the whole party by laying hands on Franklyn, and insisting he should prove that the *Earth revolved about the Sun*, before he went a step farther.

Why, said Franklyn with apparent seriousness, the Earth, as you have heard, utters her dulcet and harmonious breath as she moves along; and wherefore, then, should not I, a Son of the Earth, walk and talk at the same time?—Come! you shall hear all about it, as we stroll onward.

I am not surprised, continued he, that Reginald should be so unwilling to "disbelieve his eyes," as he would call it: for the Sun *appears* to move round the Earth in the course of a year, with as much evidence as it *appears* to move round the Earth in the course of twenty-four hours. Yet we have seen that the latter motion, however apparent, is altogether unreal; and this alone might teach us to consider, at least, whether the former also might not be unreal. The Ancients, indeed, with the exception of a very few sagacious philosophers, such as Pythagoras, or, as it is said, Numa Pompilius, a century before him, firmly believed that the Sun did perform an annual revolution among the fixed stars: and this system of the World held its place amongst all *but* a few philosophers until the time of Newton,—scarcely an hundred years ago! Nay, it was made a point of faith by the Romish Church; and Galileo, the "Tuscan artist," as Milton calls him, was thrown into prison by the Inquisition for denying it. He first, by mathematical reasoning, established the fact of the Earth's annual revolution, which Copernicus only asserted in a work he did not live to see published, having kept it for thirty years in his closet, through dread of popular prejudice and ecclesiastical persecution. At the present day, when almost every grown person is aware of the true System, it appears not a little ridiculous to see, in an edition of Newton's Principia, superintended by two Jesuits, a formal declaration at the commencement, that although in their Notes to the work it was necessary to *suppose* the Earth in motion, yet they, for their parts, did not believe such an heretical fable. The poor Jesuits, no doubt, held up this document as a shield against the fiery darts of persecution; a want of shrewdness, understanding, and knowledge, has never been the reproach of that order; but it is sufficient to evince the strong feeling which existed, at least in Catholic countries, against this, now one of the most ordinary truths of Astronomical education.

But, Franklyn, said Reginald, *I* never observed that the Sun moved amongst the fixed stars. How could I? or any one else? The Sun does not shine by night, when the stars are up: so it is ridiculous.

My dear boy, said Franklyn, before you assert any thing to be "ridiculous," take care that it is not only your opinion which is so. Listen awhile, and when you fully understand what you would deny, then deny it if you choose.

Do you see that very remarkable collection of bright stars, somewhat in the form of a *long diamond*; with a belt of three others crossing it, and various *asteroids*, or little stars, sprinkled about? See! here is a gravel-sketch of it; with two clusters over the right shoulder, and one very bright star in a line with the belt, and below all.

Each cried out that he or she saw it; and, as usual, every one saw it *first*. [See the Engraving at the head of EVENING III.]

That assemblage of stars and asteroids, exclusive of the two clusters and the luminary beneath all, is denominated a *constellation*, from the two Latin words *con*, with or together, and *stella* a star,—signifying in union *stars-together*. And the whole sky, added Franklyn, has been parcelled out into similar constellations; to each of which are assigned names, either from caprice, for compliment's sake, or because of some fancied resemblance to real or imaginary objects. Thus we have seen, that the seven stars I first pointed out are called indifferently, the *Plough*, *Wain*, or *Great Bear;* and these stars, with their company of Asteroids, form a Constellation under such names. *Orīon* is the name of the present constellation; this being the niche appropriated to a certain *giant-hunter* so called, who was slain by Diana through jealousy, and translated hither by one of his fathers, for, though not "of woman born," he had no less than *three*, to wit, Jupiter, Neptune and Mercury. These three transverse internal stars form his *belt*, and a fourth lower down marks his *sword-point*, the blade itself being left to your imagination.

Is it to this warrior that Milton alludes, said Eugenia, where he speaks of

> "Angel forms, that lay intranced
> Thick as autumnal leaves that strow the brooks
> In Vallambrosa, where the Etrurian shades,
> High over-arched, embower; or scattered sedge
> Afloat, where with fierce winds *Orion armed,*
> Hath vexed the Red-sea coast, whose waves o'erthrew
> Busiris and his Memphian chivalry."

The same, replied Franklyn; and the most judicious of all poets arms him, not with a sword, but with "winds;" agreeable to the ancient nautical opinion, that the rising of this constellation just before dawn portended rains and storms. Thus also Virgil,

> "Dum pelago desævit hyems et aquosus Orion."
> "Whilst upon the ocean rages winter and the *watery* Orion."

What is the cluster of stars in the form of a V above his shoulder called? said Isabel.

Being so near the watery Orion, answered Franklyn, it could hardly escape obtaining a kindred character and surname: those five stars are called the *Hyades*, from a Greek verb *huo*, to rain: but the very bright one enjoys a magnificent Saracenic title—*Aldebaran*, which I beg you will remember.

What! exclaimed Reginald; did those barbarians know any thing of Astronomy?

Yes, replied Franklyn; those *barbarians* were an elegant and civilized people, when their now civilized despisers, the Europeans, were degraded and ignorant slaves,—about the eighth and ninth centuries. *They* preserved and cultivated Sciences and Arts, which *these* had wilfully lost and neglected to regain. It was at the sacred fire, kept burning in the Saracen temples of knowledge, that the light was rekindled, which has since diffused its splendour through the Christian world. From the princely Moors of Spain, and the Mahommedans of Arabia, Damascus, Bagdat, &c., we derived our new-birth to learning and civilization. But to return: that lowermost star of all is called *Sirius*, or the *Dog-star*, whose rising just before dawn happened in the month of August, and thence came to be looked upon as the patron of heat, fever, mad dogs, and poets. Thus Pope, in his celebrated Epistle to Dr. Arbuthnot—

> "The Dog-star rages; nay, 'tis past a doubt,
> All Bedlam, or Parnassus, is let out!
> Fire in each eye, and papers in each hand,
> They *rave*, recite, and *madden* round the land."

We might perhaps derive its name from *Seirios*, or *Seir*, a word equivalent to our *Sire*, or *lord*, because the rising of this star regulated the agricultural seasons of the Egyptians, with whose sovereign deity, *Osiris*, it had probably some connexion.

But we have wandered, amongst all these stars and constellations, from the object we set out with,—the Earth's revolution round the sun, observed Isabel.

Towards it, you will find, replied Franklyn. Besides that my hearers require some preparatory information, ere they can understand a solution of their questions; I prefer leading them imperceptibly onward, till they find themselves perhaps admiring some beautiful features in the Temple of Knowledge, before they think its vestibule has been entered. I have an opportunity, likewise, of insinuating, as I proceed in this devious manner, a good many *side-truths*, as, for example, the particulars about Newton, and other founders of Astronomy; those about Orion, the Saracens, Sirius, &c., which I should have to communicate, at some time or other; and, finally, a comment or an illustration suggests itself now and then, which I would hope you may not find altogether useless, though perhaps not directly so in Astronomy. You must therefore pardon the "extravagant and erring Spirit" that prompts my discourse; but which, nevertheless, I always, to the best of my power, so regulate, that it shall approach its destined goal, whilst it seems only to circle round it.

I think I can perceive, said the Colonel, whither all this starry disquisition of ours has tended. You wish to explain the mode of the Sun's apparent progress through the Constellations.

Exactly so; and you will perceive we have made great advances towards that object. The *Hyades* belong to a Constellation, named *Taurus*, or the *Bull*, which is one of those that the Sun appears to travel over. Its breadth from the Hyades, westward, is determined by that other cluster of asteroids, entitled the *Pleiades*. These are a second set of transformed and translated mortals, sisters of the *Hyades*, and daughters of Atlas, king of Mauritania, who had of old, as you know, the very onerous task of supporting the Heavens on his shoulders,—a task which he latterly seems to have shrunk from, wisely leaving it between "Andes, Giant of the Western Star," and the Himalayan Dhawalaghiri, monarch of the eastern mountains. The rising of this cluster, a little before dawn, was considered propitious to navigation; and hence its name, from the Greek *ple-ein*, to sail. A pretty fable concerning it was, that, whilst in their human state, all the Pleiads but *Meropé* had deities for their suitors; she alone married a mortal, and hence her star is seen *dim* amongst those of her sisters. But leaving her to beweep her degradation, pass onward a little to the west, and you immediately enter the precincts of another constellation through which the sun passes,—*Aries*, or the *Ram*, illuminated only by one remarkable star, which is the first of that sort you meet with in a straight line, connecting the uppermost great star of Orion and Aldebaran. Observe that luminary well; it is a sort of *key-star*, to unlock the mysteries of the solar system. For this reason, and as the Constellation Orion is not always visible, I had better show you another way to find this key-star in Aries; which will give me, by the way, an opportunity of introducing you to a few other "bright little gentlemen," as Eugenia calls them.

Pray do! said the Girls, one echoing the other. We are very anxious to know at least the most illustrious of this glittering assembly.

Look, then, at that very long train of first and second-rate stars, which almost stretches across the whole court of Heaven, arranged in the following order: [and he drew them on the gravel, just above the other figure. See Engraving at head of this EVENING.]

This train of stars exhibits the principal ones of five new constellations; and I have traced out the lines which separate the whole *eight* from each other. Beginning at the right hand of the new set, they are respectively named *Pegasus*, *Andromeda*, *Perseus*, *Auriga*, and *Gemini*. The latter is so called from those two stars in it, which are somewhat *twin*-like, and on that account are denominated (the brightest) *Castor*, and (the other) *Pollux*, after those renowned warriors of antiquity, the twin-born progeny of Jove; or, as Dryden more particularly describes them,

> "Fair Leda's twins, in time to stars decreed,
> One fought on foot, one curbed the fiery steed:"

Castor being the patron of horsemanship, and Pollux of pugilism. This constellation is a *third*, into which the Sun passes from Aries and Taurus. But to find the principal star in Aries: Of the three stars in Perseus, look along the two nearest Auriga; and if your eye proceeds in that direction, between Taurus and Pegasus, it will fall upon the said key-star, in a line running through Aldebaran, the lower Pleiad, and the lower star in Pegasus.

Nearly so, observed the Colonel.

Yes, replied Franklyn; if Jupiter were any thing of a *martinet*, and would transform me into a serjeant of the stars, I would drill them into better order. Till some appointment of that kind, you must not expect to find them marching, rank and file, in accurate right lines, like your own regiment. But what a sad trial is not Reginald's patience undergoing all this time! I really must attend to his question, without any further digression.

Only—only just tell me, said Isabel, what is that beautiful bright star, on a line with the two uppermost of Orion, and nearly as far from them on one side as Aries on the other.

Is this reasonable of you, Miss Inquisitive? said Franklyn. However, resistance is vain!

> "O Beauty! Syren! fair enchanting good!
> Sweet silent rhetoric of persuading eyes!
> Dumb eloquence, whose power doth move the blood,
> More than the work or wisdom of the wise!"

That star is called *Procyon;* and is the principal of a small *Constellation* round it, entitled the *Little Dog*, or rather the *Dog-Leader*, as its Greek name signifies (*pro* before, and *kuon* a dog), referring to its position in front of Sirius, or the Dog-star. Now tease me no further!

Then addressing himself to Reginald: If, about the end of April, you looked westward, some time after sunset, the sky being sufficiently clear, you would perceive, not much above where the sun went down, the *key-star* I have shown you. If, about the end of May, you looked in the same direction, at the same hour, you would not find that key-star, but the *Pleiades* or *Hyades* nearly over the place where the sun went down. Again, if about the beginning of July you looked westwards (only a little more to the north than before), you would not find either *Pleiades* or *Hyades*, but the *Twins*, Castor and Pollux. About the beginning of August, you would find that a very bright star, considerably to the east of the Twins, had taken their place over the point of sunset, while they were below the horizon. In about two months more this bright star would not be found over the point of sunset, but another, whose situation in the heavens is far more easterly. And in like manner, stars more and more easterly in the Heavens, would be found, month after month, hanging over the point of sunset; till at length, at the end of twelve months, the *key-star* would be found there again! Now, what does this show, but that the above-mentioned series of stars, reckoning from the key-star easterly, has rolled, as it were, successively over the point of sunset? or, in other words, as the sun is only just below its setting-point, rolled successively *past the Sun?* and that this revolution went on perpetually, just ending where it began, namely, with the key-star of Aries?

But the very same effect would be produced, whether this series of stars rolled westward past the sun, or the sun rolled *eastward* past the stars. If, setting out from the key-star in Aries, he rolled successively past the Pleiads, Hyads, Twins, &c. in an easterly direction, these would appear successively to roll past *him*, in a *westerly* direction, as I have just explained. Let us, for the present, suppose that it is the sun which moves easterly among the stars: I will enumerate, both in Latin and English, the Constellations, *twelve* in number, through which he passes, in making an entire revolution; and, moreover, show you the symbol by which each is characterised in astronomy:—

1	2	3	4	5	6	
Aries,	Taurus,	Gemini,	Cancer,	Leo,	Virgo,	Libra.
Ram,	Bull,	Twins,	Crab,	Lion,	Virgin,	Scale.
♈,	♉,	♊,	♋,	♌,	♍,	♎,

8	9	10	11	12
Scorpio,	Sagittarius,	Capricornus,	Aquarius,	Pisces,
Scorpion,	Archer,	Goat,	Waterman,	Fishes.
♏,	♐,	♑,	♒,	♓.

Beginning from Aries, the sun appears to move, in a great circle, round the Heavens, through these constellations in succession, until at the end of twelve months, or about 365 days, he comes to Aries again, from whence he proceeds as before.

So that, observed Eugenia, he is about one month passing through each constellation.

That would be so, if *they* were equal in length, and *he* were equable in motion; neither of which is the case. The great circle, however, in which he moves, runs pretty nearly through the middle of the whole twelve, which extends, in breadth, about eight *degrees*, or sixteen times his own diameter, on each side of it; so that the whole *belt* of constellations is about sixteen degrees broad, and is exactly 360 degrees long. This belt is called the *Zodiac*, from *zodion*, the Greek for animal, as it is occupied by the celestial residences of so many, both rational and irrational, man, monster, virgin and scorpion, &c. &c. besides a *pair of scales*, which we may suppose held by that purblind goddess, Astræa, or Justice. The great circle itself, through which the Sun appears to move, is called the *Ecliptic*, because eclipses happen when the Moon is in or very near it.

The Ecliptic, then, said Isabel, is with regard to the Heavens, what the Equator is with regard to the Earth.

It is, replied Franklyn, so far as this, that it divides the whole sphere into two equal parts or hemispheres; but if the plane or surface of the terrestrial equator were spread out till it cut the Heavens in a huge circle, this circle would *not* be the Ecliptic. This would be the *Celestial Equator*, from which the celestial pole would be every where a whole quadrant of the Heavens distant. You manifestly perceive, however, that the constellations of the Zodiac which I have shown you are not all at the same distance from the pole; and, if you could see the entire belt at once, you would observe that only two points of it, one near Aries, and the other near Libra, exactly opposite, were a quadrant from the pole; whilst Taurus, Gemini, Cancer, Leo, and Virgo, were all gradually approaching the pole: Scorpio, Sagittarius, Capricornus, Aquarius, and Pisces, all gradually receded from it. In fact, if you imagine the Ecliptic and the *celestial* Equator actually drawn on the Heavens, *one half* of the former would be to the *north* of the latter, and the other half to the *south*, while both great circles would intersect in two exactly opposite points of the celestial sphere, called *equinoctial points*, from the Equator or Equinoctial.

Then, observed Mrs. St. George, the Sun moves, or appears to move, in a path oblique to the celestial Equator, not in that Equator itself?

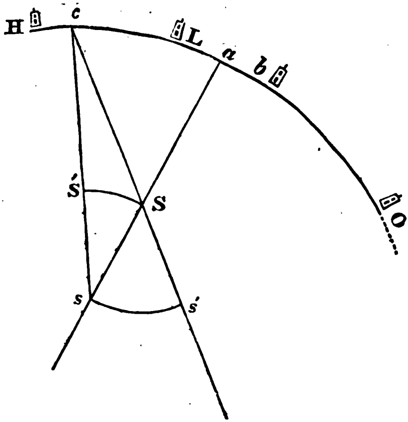
Just so. However, as this oblique path of his intersects the celestial Equator, at the two equinoctial points, he is in the Equator twice a year, but no oftener, and then but while he is crossing it. At these times, he is just over the *terrestrial* Equator, but at all others he is over some part of the Earth, to the north or south of its Equator. The inclination of his path to the *celestial* equator, or the *angle* between that imaginary circle and the Ecliptic, is called the *Obliquity of the Ecliptic*; and when he has ascended to that point of the Ecliptic farthest from the celestial Equator, he is then $66\frac{1}{2}$ degrees from the pole, or $23\frac{1}{2}$ degrees from the celestial Equator; that is to say, if you imagine a quadrantal arch from the celestial pole to the celestial Equator, and passing through the farthest point of the Ecliptic from that Equator, the part of this arch, intercepted between the two circles, would be something less than a *fourth part* of the whole; namely $23\frac{1}{2}$ degrees, which is considered as the measure of the obliquity of the Ecliptic.

But I do not see, cried Reginald impatiently, how all this proves that the *Earth moves round the Sun.*

There again! exclaimed Franklyn; he expects me to move the Earth with as little difficulty as Archimedes, the geometer of Syracuse, when he asked merely for a "place where he could *stand*," in order to do so!—No: "all this" certainly does not prove that the Earth moves round the Sun; it is only a preparation to prove it. You will grant, however, I suppose, that it proves the Earth *may* move round the Sun, and so produce all the appearances we have described, on the hypothesis that it were the Sun, or the Heavens themselves, which moved?

Why, how could the Earth moving round the Sun, make the Sun appear to move round the sky?

Suppose S, and *s*, to be two ships on the ocean; H, L, *b*, O, four *lighthouses* at some distance, seen on the horizon H L O. It is plain that a spectator in *s* would see S in the direction *s* S *a*, and if the vessels were far asunder, would imagine S to be at *a* on the horizon, between the lighthouses L and *b*. If, now, S were to move into the place S′, while *s* remained stationary, the spectator would hereupon imagine S to be at the point *c* on the horizon, towards which it would seem to have moved, not in the arch S S′, but in the horizontal arch *a c*, past the lighthouse L. If, on the contrary, the ship S were stationary in its first place S, and the ship *s*



moved the other way, through an arch *s s′*, in this case, the aforesaid spectator would, at the place *s′*, see S in the direction *s′* S *c*, and would imagine S to be at the same point *c* on the horizon as before, towards which it would seem to have moved in the same horizontal arch *a c*. Hence we perceive that the very same appearance would be produced, whether *s* were at rest and S in motion, towards one side, or S were at rest and *s* in motion, towards the other side; in both cases, a spectator in *s* would imagine S to have moved in the circle H O from *a* to *c*. Is not that very manifest?

Nothing can be more so.

Is it not likewise equally manifest, that the same appearances would take place, if while *both* ships were stationary at S and *s*, the horizon itself were carried round, lighthouses and all, in the direction

H O; for, first, the lighthouse L would move up to the line s S a, and then the point c would move up to this same line?

Yes.

Here then is a familiar illustration of the predicament in which we have stated the Sun, the Earth, and the Heavens to appear.—Conceive the Sun to be a vast *fireship* blazing amidst ether; this globe of ours to be a *skiff* upon the same element; and the Zodiac, with all its stars, to be a ring of *lighthouses*, encompassing both. From the illustration just given, it is plain, that whether the Sun moves in one direction, or the Earth, or the Zodiac, in an opposite, which ever of these three motions actually takes place, the Sun will *appear* to move in the Zodiac.

Well! and now show me that it does *not*, cried Reginald.

And show *me* that neither it, nor the Zodiac moves, but the Earth itself! said Isabel.

Here is a dilemma! exclaimed Franklyn.—You remember what our rhyming Friend wrote with his pencil, on an Egg which a Lady had given him, both for subject and paper:—

> "Was ever yet so hard a task
> To any Bard assigned?
> How can I grant you what you ask
> When to an *egg* confined?"

How can I grant you what you ask, when confined to this terrestrial egg, hatched, as some ancient philosophers imagined, by primeval Night, and certainly not the size of a humming-bird's, in comparison with the huge "Mundane Egg,"—the Universal Orb of Things,—which other philosophers as wisely conceived to have been produced, in that form, by Nature *? And, the truth is, a much more profound Astronomer than I, would be at a loss to bring forward any evidence that the Earth moved round the Sun, rather than the Sun round the Earth, or the Zodiac round both,—any evidence which, *to you*, would be sufficiently conclusive. Not but that such evidence exists. In the present stage of your acquaintance with Natural Philosophy, however, you could not understand its force; nay, not even the meaning of the terms in which it must be conveyed. I can, therefore, only submit to your common-sense such a proof, as it alone will enable you to understand. With this you must "stay the stomach of your curiosity;" other proofs will accumulate along with your astronomical knowledge.

In the first place, then, it is manifestly very improbable, that the whole Heaven of stars should

* "He, desiring to raise up various creatures, by an emanation from his own glory, first created the waters, and impressed them with a power of motion: by that power was produced a *Golden Egg*, blazing like a thousand suns, in which was born Brahma."—Hindu Mythology. *See Asiatic Researches, Vol.* I.

This "Golden Egg" was the Universe; a creed which some of the Grecian Sages adopted.

move round the Earth and Sun, once in every year; for each of these luminaries being, as we have seen, at such an immeasurable distance from us; each being of such vast magnitude, as is apparent from their being visible at such distances; and, including the *telescopic* stars, namely, those discoverable by means of telescopes, there being such a countless multitude of these luminaries, far beyond the powers of enumeration to specify;—for all the said reasons, it would be a vast stretch of credulity indeed, to believe that this whole system of bodies annually revolved about the Earth and Sun, for no other purpose that has yet been observed, but to afford a very dubious light, which hardly enables us to step cleanly over a kennel. All the same phenomena are explicable, on the supposition of a yearly revolution in the Earth or Sun; and either of these being a far more simple hypothesis, we are bound to consider them both as more probable than a yearly revolution of the whole Heavens.

In the second place, it is much less probable, that the Sun moves annually round the Earth, than that the Earth moves annually round the Sun. For, it is a matter of fact, which allows of mathematical demonstration, and of which I will, hereafter, give you satisfactory proof, that the Sun is above a *million of times* larger than the Earth, and that he is nearly *one hundred millions* of miles distant from her. Now what a vast force must be continually employed to whirl such a body, at such a distance, round the Earth every year; and what an enormous *waste* of force too there would be, when the very same effects might be produced by whirling the lesser body, in the same time, about the greater! Common sense obliges us to adopt the latter hypothesis, in preference to the former; especially when we have shown that no weight is to be laid on the *apparent* stillness of the Earth.

Nevertheless, Franklyn, said Eugenia, you must allow that this is only a *probable* proof of the Earth's annual motion round the Sun.

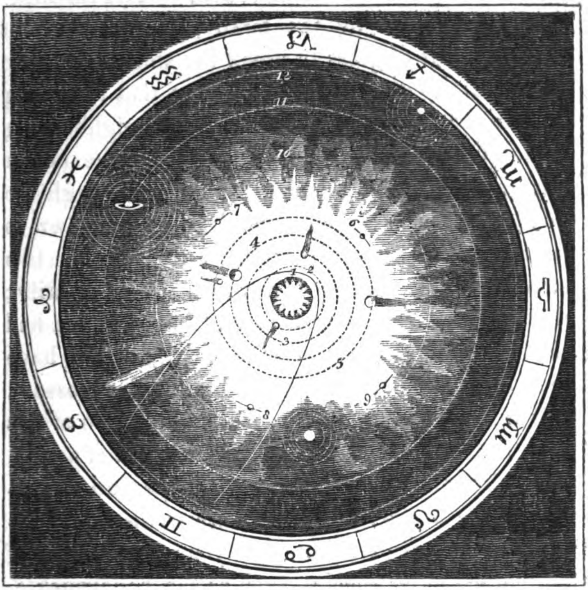
And only as such do I give it, replied Franklyn. Any of the three hypotheses might be chosen; but I choose this as the most probable. Taking it for granted as the true one, I shall proceed to enumerate the phenomena of our System; *all* of which it will serve to explain, and *some* of which neither of the other hypotheses will serve to explain. What must be acknowledged then?

O! that this, undeniably, is the true hypothesis! it will then be no longer probable, but certain, admitted every one.

But is the Sun such an immense body, and at such an immense distance, as you said? inquired Reginald.

We will discuss that subject at our next conversation, said the Colonel. I am sure Franklyn must be quite fatigued—

As a young fox, after being almost run down, Colonel! added his Nephew rising, however, on his toe with as much buoyancy as ever. Let us adjourn to the Library, where I will show you on the Celestial Globe, more plainly than I could by description, the relative position of the Equator and Ecliptic.



EVENING FIFTH.

At an early hour next Evening, the Party found themselves in an arbour which just fronted the western sun, and from whence they could perceive him gradually descending, in cloudless glory, beneath the horizon. This arbour was seated in a pleasant acclivity, to the top of which a "pleached alley" wound gently from the lawn. Upon the west, nothing interrupted a boundless view over meadows, and woodlands, and rivulets, to the very *celestial* horizon itself: in that direction, "Arbour-hill," as it was called by the family, sloped, without almost a tuft of grass to break the smooth verdure of its coat, down to a green hedge that ran along the bottom, and divided it from a neighbouring park. On every other side, however, the bower was surrounded by a dense shrubbery, through the slender trunks of which several paths led down to the orchard. It was a favourite retreat for the two girls; and, indeed, they had woven it very prettily; almost every tree, and shrub, and flower, which had beauty or fragrance to recommend it, might have been discovered thrusting in a branch or a blossom, as if anxious to share in the gazer's admiration of this structure. A slight but strong framework of acacia, vine, lilac, and osier stems, gave shape and steadiness to the whole; but these were trellised and interlaced by the tendrils and young branches of numberless other species, such as the honeysuckle, jasmine, ivy, laburnum:

"The roof
Of thickest covert was inwoven shade,
Laurel and myrtle, and what higher grew
Of firm and fragrant leaf; on either side
Acanthus, and each odorous bushy shrub
Fenced up the verdant wall; each beauteous flower,
Iris all hues, roses, and jessamine,
Reared high their flourished heads between, and wrought
Mosaic; underneath the violet,

Crocus and hyacinth, with rich inlay
Broidered the ground, more coloured than with stone
Of costliest emblem. * * In shadier bower
More sacred and sequestered, though but feigned,
Pan or Sylvanus never slept, nor Nymph
Nor Faunus haunted."

From its close texture, and perhaps with some allusion to "those that dwelt therein," Franklyn had christened this bower the *Birdcage;* and it was at his instance, that, besides its especial owners, the Birdcage held within its wicker walls so many guests this evening. It was certainly not the place either for a Nun or a Hermit: yet the quietude of its situation, and the still magnificence of scene before it, was by no means ill calculated to produce sober, if not pensive reflections, in the bosom even of the most worldly-minded: especially, at that hour, when the most glorious and pre-eminent of all worldly objects, fallen from his high estate, appeared to sink into the grave of obscurity.

Yes! said Franklyn, how insignificant must this Earth appear to an inhabitant of the Sun, perhaps now surveying it descend below *his* horizon, as he stands, like me, at the door of his arbour! Our orb does not appear to him *one-hundredth* part the size of his orb to us; and, instead of an enormous globe of splendour, he sees nothing but a speck of dull light, the wan reflection of his own lustre,—if he sees it at all! And as for *us*—us individual *grains* of the Earth—nay, not so much!—but mere "atomies" of dust—if he were Uriel himself,

"The sharpest-sighted Spirit of all in Heaven,"

he could not discern an army of us!

What a vast field of speculation your words spread open before us! exclaimed the Colonel. They suggest a thousand questions and inquiries, in a moral as well as a scientifical point of view. Is it then your opinion that the sun,—a globe of living fire! whose heat, even at the incredible distance you mentioned, is enough to scorch the flesh black, and turn half the earth into a desert of sands!—can that orb of solid flame be trod by a single "inhabitant?"

At an interval of near one hundred millions of miles, replied Franklyn, it becomes a matter of some difficulty to ascertain the nature of any body, even so large as the Sun, and particularly to decide whether or not it is inhabited. But let us proceed gradually to consider what has been discovered, with regard to the Sun, in an astronomical point of view; we shall then, perhaps, find ourselves better qualified to discuss such metaphysical questions as you now propose.

In the first place, like the Earth and Planets, he *revolves upon an axis.*

Dear Franklyn! exclaimed Isabel, how can that be ascertained? The Sun revolve upon an axis!

Have you already forgotten how it was ascertained, that the planets so revolved?—By the movement of spots upon their surfaces. In like manner, spots upon the solar surface, many of them visible to the naked eye, are observed to move from the eastern edge westwards, and, upon reaching the western edge, to vanish gradually: in about thirteen days and a half, they gradually appear again at the eastern edge, and in about the same period vanish again at the western. Dr. Herschel observed one of these spots, which was more than 30,000 miles broad. Now, the conclusion evidently to be drawn from these observations is, as in the case of the planets, that the Sun revolves upon an axis, carrying these spots with him; and that, moreover, he, as well as each of them, revolves from west to east, just as the *Earth* does,—another point of resemblance between all these bodies, momentous in proportion to its very minuteness, as so close an analogy in small things betokens a similitude in great.

The Sun, then, makes one complete revolution in 27 days? said the Colonel.

In somewhat less, replied Franklyn; for when a spot sets out from the eastern edge, for example, to move over the visible disc of the Sun, you must consider, that the Earth likewise moves, at the same time, about the Sun, discovering more and more of its western side every day; so that, at the end of $13\frac{1}{2}$ days, when the spot reaches the western edge of the Sun, which is *then* visible, it will have moved over more than the disc at first visible, by so much of the western side as we discovered by the Earth's motion. In about 13 days, therefore, it would have moved over the disc first seen; and, as we see only the hither half of the Sun, we may reckon about 26 days for the whole period of the spot's revolution; or, at it has been more accurately computed, 25 days 10 hours, which is the time of the Sun's rotation on its axis.

Most wonderful! exclaimed Isabel, that such exactness can be attained in what, I at first thought, was wholly undiscoverable.

There are few studies, observed Franklyn, more calculated than Astronomy, both to elevate and depress us in our own opinions. When we reflect upon our discoveries, among spheres so remote, we are inclined to look upon ourselves as *little divinities*, who can fathom so many profound mysteries, instituted by Supreme Wisdom. On the other hand, when we consider how diminutive and insignificant a human creature is, surveying from his little platform of earth those self-same spheres, so remote and so enormous, he himself being invisible to the nearest, —we are apt to lose all sense of our own dignity and importance. Every farther discovery of such bodies is a farther degradation of ourselves; as the circle of our astronomical knowledge increases, we, at the centre, appear to diminish, and, if the circumference could embrace Infinity, we should, at the same time, vanish into nothing. But, after all, this extreme humility is as irrational as that presumption; for it is not by corporeal dimensions that our true grandeur is to be estimated; a spark of mind is more worthy than a mass, however large, of blind matter. I have wandered, however, from the subject. Having established that the Sun revolves, it necessarily follows that his body is globular, inasmuch as, unless it was so, it would not *always* exhibit a *circular disc.*

That is conclusive, said the Colonel; and, for the same reason, those *planets* also, which have been proved to revolve, must be globular.

We have seen, too, added Franklyn, that the *Earth* is globular: so here is a *third* point of resemblance between Sun, Earth, and Planets!

Yes, said Mrs. St. George, but before you can prove, that the Sun is inhabited by human beings, you must establish another point of resemblance between it and the Earth; namely, that both are *globes of fire.*

I have yet an alternative, said Franklyn.

What can that be? was repeated by the whole circle.

Why, to show that *neither* is a globe of fire.

"Neither!" ejaculated the Colonel whilst all the rest seemed to be struck dumb with amazement at the coolness with which Franklyn committed this outrage upon common sense. Do you, then, pretend to say, that the Sun is *not hot?* Come! come! this is one of your paradoxes.

In Literature whose object is entertainment rather than instruction, replied Franklyn seriously, I have no objection either to see a paradox, or to sustain one. But such things are, in my mind, very much out of place, where knowledge is to be communicated; nay, they are more than inappropriate, they are injurious.

Fair Sir! be not so deeply impressive in your discourse, so very Johnsonian! cried Isabel. Answer me to this: you behold that,—said she pointing him out the Sun, at which every one had been staring for the last quarter of an hour—

Ay, that splendid vehicle of light and heat—

"With wheel yet hovering o'er the ocean brim,"

if we could only see the ocean!

Well! continued his fair cross-examiner, and yet you assert that this "orb of flame," as you called it yourself, is not a *globe of fire?*

What! inquired Franklyn on his side,—a burning mass of metal; or, at least, of *matter;* as we cannot imagine flame without something to feed and support it?

Yes, replied she, something of that kind.

Isabel reminds me of *Anaxagoras*, the Heathen philosopher! said Franklyn turning to the rest, who laughed a good deal at the striking resemblance.

Isabella reminds you of a heathen philosopher? said she repeating his words. And pray, in which of my good qualities, do I resemble that sage, grave man, Anasagoras, as you call him?

Why, somewhat like you,

> "He held the Sun was but a piece
> Of *red-hot iron*, as big as Greece!"

Another peal of laughter, in which the *heathen philosopher* herself joined unaffectedly, followed this sally.

But I did not say iron, said she; it is rather more like a sphere of molten gold.

This is "out of the smoke into the smother," as Petruchio says, rejoined her unmerciful opponent; for if you had asserted, that the material of the Sun's body was some such dark substance as iron, you would have had Dr. Herschel, or at least his observations, on your side.

Are you jesting still?

No; I am serious. That *Astronomer*, as he may be designated, *par excellence*, in the primitive acceptation of the word, which is derived from the Greek *astron*, a star, and *nomizo*, or *nemo*, to classify or bring under laws of arrangement—that Astronomer, who has explored more of heaven, than many have of the earth about them, observed, by means of his gigantic telescope, such appearances and variations about the solar spots as to leave no doubt of their arising from transitory *openings* in a luminous atmosphere, which surrounds the opaque body of the Sun. He even went so far as to measure the *shelving sides* of these openings, and detected, what he conceived to be, an *inner atmo-*

sphere, luminous like the outer, but of a far inferior degree of brightness. This inner atmosphere he judges to be a sort of veil or curtain, to defend the body itself of the Sun, from the heat and insufferable light of the outermost; and concludes that, by its friendly means, the dark and solid *nucleus*, or kernel, of this great luminary is rendered habitable. So, you perceive, continued Franklyn turning to Mrs. St. George, I have not brought a new race of living creatures into probable existence, without respectable authority. Indeed, another philosopher, with whom the notion of the Sun's habitability had likewise originated, sums up his theory in these words: "Vegetation may obtain there, as well as with us. There may be water and dry land, hills and dales, rain and fair weather; and as the light, so the season, must be eternal. Consequently, it may easily be conceived to be, *by far, the most blissful habitation of the whole system!*"

An eternal summer! exclaimed Eugenia,—

> "Where the bee banquets on through a whole year of flowers!"

To be sure, Dr. Elliot, the latter philosopher, said Franklyn, was, by several of his most intimate friends, considered as a *madman*, which, if true, would reflect no credit on our theory.

Was that the Dr. Elliot, asked Colonel St. George, who was tried, many years ago, for shooting a Miss Boydell?

The same. And this very opinion of his, which he had communicated in a letter to the Royal Society, was adduced as the most irrefragable proof of his mental derangement! A remarkable instance, amongst many, of ingenuity being mistaken by ignorant and vulgar minds for insanity.

Nevertheless, said Mrs. St. George, although it be the conjecture of such great men, it is still only a *conjecture*. And, at all events, granting it to be a fact, the beings who may, as you assert, dwell beneath such a glowing atmosphere, cannot be exactly of our species; even though we allow them to be *rational* creatures, they cannot be, properly speaking, *human*.

The reasoning of another philosopher, more profound, I believe, than either I have mentioned, Dr. Brinkley, the present Bishop of Cloyne, may perhaps satisfy your scruples. Dr. Brinkley contends, that the *matter of heat* may not actually pass to us from the Sun, but is only *extracted*, as it were, by the action of his beams on earthly substances, in which it is latent; for otherwise the temperature of the earth would be continually increasing, and would, in a few years, become intolerable. Besides, he continues, heat exists in a state of combination with earthly substances, in such a quantity, that it requires only to be extracted, in order to answer all the purposes of vegetation, &c. Is it then not unnecessary, he asks, to have recourse to the Sun for *heat*, when his *light* is sufficient? And in a similar manner, this celebrated Astronomer explains how the different planets, which are all at different distances from the Sun, may yet have nearly the same temperature; the "matter of heat" existing in their own substances being less or greater as to quantity, according to the greater or less quantity of light which acts upon it, by reason of their less or greater distances from the sun.

A most beautiful and ingenious theory!

It must not be concealed, however, added Franklyn, that if there be a Dr. Brinkley upon one side, there is a Dr. Brewster on the other. From Herschel's *own observations*, the fourth mentioned philosopher draws exactly reverse conclusions. One of those observations seems to prove, that the Sun emits *two* kinds of rays, visible or luminous, and invisible or calorific. The former are incapable of producing heat, and the latter are incapable of producing light. Hence, Dr. Brewster concludes, that it is the dense, opaque body of the sun, which emits the invisible rays endued with the power of heating, while from the brilliant atmosphere proceed those visible rays endued with power of illuminating. If such be the case, it is, indeed, extremely improbable, not to say impossible, that the Sun should be inhabited by creatures like us, or like any upon earth; although, perhaps, we can scarcely go so far as Dr. Brewster, in considering it demonstrative against the existence, in that sphere, not only of rational beings under *any form*, but of any *living* creatures whatsoever.

Certainly, admitted Mrs. St. George, one would think, that the most glorious body in the creation, the source, as we may call it, of animal and vegetable life, should not be without its appropriate inhabitants, to extol the power, and wisdom, and goodness of God.

Those who consider it merely as a vast *stove*, or *lamp*, or even *make-weight* to balance our system, have, I think, not estimated the full force of that excellent proverb, "Nature makes nothing in vain." What a vast sphere of desolation! what an immense surface of unoccupied sterility, must the Sun present, if it be really without a "living soul" to adorn it!—if, indeed, continued Franklyn in a qualifying tone; if, indeed, it be not devoted to some high and abstract purpose, some extra-human object, incomprehensible by human capacities,—if its ultimate function be of a transcendental and, perhaps, entirely metaphysical nature—

How *big* is the Sun? demanded Reginald with sufficient abruptness.

More than 100 times the size of the Earth, answered Franklyn descending at once from the sublimity of his last speculation. That is, the *diameter* of the Sun is so much greater than the diameter of the Earth; indeed, it is about 111 times the latter, so that it must be—how many miles?

888,000 miles, said Reginald immediately, inasmuch as the diameter of the Earth is 8000.

Very good. Now, if the *diameter* of the Sun be 111 times that of the Earth, can you tell me how many times the *sphere* of the Sun is that of the Earth?

111 times also.

Folly!—you do not consider.—Here is an *apple* two inches long, while your head is six inches or three times as long; but will you tell me that your head is only the size of *three such apples?* It could never hold such a store of brain as you are blest with, Reginald.

I think Reginald's head is fully equal to thirty times as many such apples, said Isabel.

You mean in *size*, not in *value*, I hope, returned Franklyn; your expression was rather equivocal. And if the two were spheres or perfect globes, they would be nearly in the proportion you guessed, namely, as *one* to *twenty-seven*, although their *diameters* were only as *one* to *three*. Again, if you *weigh* an ivory marble and ball, of the same texture and material, the diameter of the ball being *twice* that of the marble, you will find that the former sphere will weigh exactly *eight* times that of the latter; or, in other words, that there is eight times as much in the one sphere as in the other. Analyzing both these examples, you perceive that the number expressing the greater *diameter* is multiplied by itself, and the product multiplied *again* by that number, in order to obtain the comparative size of the greater *sphere.* Thus, in the first example, 3 multiplied by itself, gives 9; and this, multiplied *again* by 3, gives 27. In the second example, 2 (the number expressing the diameter of the ball, that of the marble being 1), multiplied by itself, gives 4; and multiplied *again* by itself, gives 8, which is the comparative size of the ball. And in like manner for every example: if the diameter of one sphere be *any* number of times that of another, multiply the said number by itself, multiply the result by the said number again, and this will give you the comparative size of the former sphere. Thus, if one diameter be 10 times another: Say 10 times 10 is 100, and 10 times 100 is 1000; therefore the greater sphere is 1000 times the lesser. Reginald will now tell me the comparative size of the Sun to that of the Earth.

Reginald, gazing intently at the apple, as if it contained the whole secret, managed to stammer out—The diameter of the Sun is 111 times the diameter of the Earth—therefore—therefore—I am to say 111 times 111 is—

12,321, twelve thousand three hundred and twenty-one.

Then 111 times this is—

1,367,631, upwards of thirteen hundred thousand; so that the sphere of the Sun is upwards of 1,300,000 times the sphere of the Earth, or about a *million and a quarter* of times as large.

Wonderful!—The Moon then is, I suppose, just as many times the size of the Earth, said Isabel.

Wherefore should you think so?

Because, replied Isabel, the Moon and Sun appear to be just about the same magnitude.

But, recollect, Miss Rosebud! (as he sometimes playfully called her), that the Moon is about 200 times *nearer* than the Sun.

How particularly stupid I am this evening! said Rosebud.

Oh! by no means, subjoined Franklyn in a voice of pretended soothing; I never knew you more brilliant!—Come! said he laughing at his own ungallant equivoque; you shall compute the Moon's size mathematically; and so recover your self-satisfaction. By observation we know that the Moon's diameter is about 2000 miles, or one-fourth of the Earth's diameter: now, what is the comparative size of the Moon's sphere?

Blushing with anxiety to prove herself not altogether so "stupid" as she had said, and which indeed was far from true, Isabel rapidly went through the computation.

As the Earth's diameter is 4 times that of the Moon, I say, 4 times 4 is 16, and 4 times 16 is 64; therefore the Earth's sphere is *sixty-four* times the Moon's sphere.

Good girl! said Franklyn a little more paternally than his age warranted. Consequently, the

Moon is about *one-sixty-fourth* as large as the Earth. This comparative size will of course be different, according to the relative diameter of these two bodies; it is sometimes stated at *one-forty-ninth*, and this is perhaps nearer the truth, the Moon's diameter being probably more than one-fourth that of the Earth.

How is that known? inquired Eugenia. How is it possible to know what length the Moon's diameter is, when she is at such a distance from us?

I will endeavour to explain this, replied Franklyn; or rather, to satisfy you that it *can* be done; for the process by which we calculate the diameter of a heavenly body is essentially mathematical, and therefore I am unable to give *you* such a popular description of it as you would understand. However, you shall acquire a very sufficient idea of this inconceivable process, as I hear you call it; this *daring* process, as it may indeed be called, by which man has attempted, and successfully attempted, to quit his native earth, and step from star to star. In the following detail, likewise, I shall find many opportunities of introducing several astronomical terms, as well as truths, with which you should be acquainted.

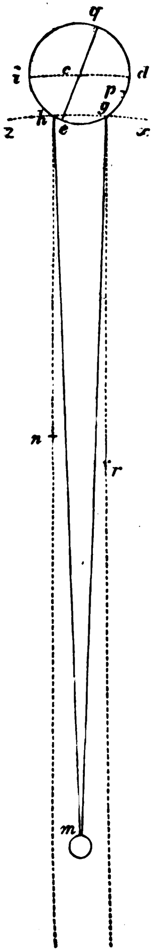
In our last night's conversation, (page 84.) you learned how the imaginary circumference on the heavens, designated *celestial* equator, was formed: namely, by supposing the plane, or *flat*, of the *terrestrial* equator, to be spread out until it intersected the concave sky. In like manner, almost all the circles which we conceive to divide the Earth's surface have corresponding imaginary circles (only sometimes with different names), on the sky's surface, which are formed, like the celestial equator, by supposing the plane of each to be spread out until it intersected the celestial sphere. Thus a terrestrial *meridian*, which is a great circle of the *Earth*, passing through the terrestrial pole and axis, has a corresponding *celestial* meridian, which is a great circle on the *heavens*, passing through the *celestial* pole and axis. [Observe, once for all, that I shall speak of these circles, or circumferences, as if they had a real existence, instead of being imaginary.] Likewise, as the distance of a place on the Earth from the terrestrial equator is reckoned on an arch of the terrestrial meridian between that place and the terrestrial equator; so the distance of a point or object on the heavenly concave from the celestial equator, is reckoned on an arch of the celestial meridian between the point or object and the celestial equator. But, instead of the latter distance being called the *latitude*, it is called the *declination*, of the point or object; and is moreover characterized as *north* or *south* declination, according as the point or object lies on the same side of the celestial equator with the north or south celestial pole.

The point of the celestial meridian exactly over a terrestrial place is called, from an Arabic word, the *zenith* of that place; in more accurate terms, a radius of the Earth, passing through a place on its surface, and lengthened sufficiently, will intersect the celestial meridian in a point which is called the zenith of that place *. If that radius be lengthened through the Earth's centre *the other way*, until it meets the celestial meridian in a point opposite to the zenith, that point is called, from another Arabic word, the *nadir*. So that the nadir of a place is that point of the heavens exactly under it, as the zenith is exactly over it.

[See the Engraving at the head of EVENING II. The word ZENITH is near the 50th degree of the celestial meridian; therefore, if upon the Earth, exactly beneath, London (whose latitude is $51\frac{1}{2}$ degrees) were situated, this Engraving would exhibit that capital with its *zenith* and *nadir* above and below.]

Our preliminary object, in the grand process of finding the length of the Moon's diameter, is to find the apparent breadth of the Earth to an imaginary spectator on the Moon. Here I have drawn a figure to assist us; if there be light enough to see it.

* A celestial circle, corresponding to a terrestrial meridian, is generally called, from the circumstance previously mentioned, a *Circle of Declination*, instead of a *Celestial Meridian;* which should be only applied to that circle of declination passing through a spectator's *zenith*.



Gibraltar, you perhaps know, lies about 36 degrees north latitude, and St. Helena about 16 degrees south latitude; these two places being nearly on the same terrestrial meridian. Let *g* and *h* represent them, while *i h g d* represents the meridian passing through them, and *e* the point of the equator *e q* between them. Now, suppose that *m*, the Moon, is on the corresponding *celestial* meridian, and over some place between *g* and *h*. Suppose, also, that straight lines *g r*, *h n*, are drawn from the two former places towards a fixed star on the same celestial meridian with the Moon, and having nearly the same *declination*, but on account of its great distance visible behind the Moon at Gibraltar, in the line *g r*, and at St. Helena in the line *h n*. These straight lines, I have already shown you, lie in the same direction, that is, are every where equally asunder, or *parallel*, by reason of the said immeasurable distance at which the star is fixed.

Now, if *m* be the place of the spectator at the Moon, and if straight lines *m g*, *m h*, be drawn from that point to *g* and *h*, then *g m h*, the angle at *m*, will be the angle at the Moon, spanned by the distance between *g* and *h*. But this angle is equal in width to the *two* angles *m g r*, and *m h n*, at *g* and *h;* of which you may satisfy yourselves, if you please, by cutting two pointed pieces of paper, which will exactly fit into the latter small angles; joined together, they will fit exactly into the greater angle *g m h*, which shows that *this* is equal to the other *two* together *.

These things being premised, what have we now to do but measure the two latter angles, in order to know the size of the one greater angle; namely, the angle at the Moon, spanned by the distance between *g* and *h*? And how do we measure these angles? Thus:

Let one person at Gibraltar observe the arch of the celestial meridian between the moon and the star: say he finds it to be less than the 360th part of the whole circle, or about three-quarters of a degree; this will be the width of the two lines *m g*, *g r*, or the size of the angle *m g r*. Let another person at St. Helena make a similar observation; say that he finds the arch between the Moon and star to be a quarter of a degree; this will be the

* The mathematical proof of this truth is easily derivable from ARTICLES 35 and 12, DARLEY'S POPULAR GEOMETRY, by continuing *g m* to meet *h n*.

width of the two lines *m h*, *h n*, or the size of the angle *m h n*. Consequently, adding these two quantities together, one degree will be the size of the angle *g m h*, which we have shown is equal to the two little angles just measured.

In this manner we have computed the apparent breadth between *g* and *h* to a spectator in the Moon. If he looked at the Earth from *m*, when Gibraltar and St. Helena were situated *under* him, as represented in our figure, the breadth between them would appear to be one degree of a circle *x g h z*, in whose centre *m* he stood, and which passed through those places. But, if we drew two straight lines from *m*, just touching, or grazing, the Earth at *d* and *i*, then *d c i* would be the whole apparent breadth of the Earth to a spectator at *m*. And having already computed the apparent breadth *g h*, we have only to increase it to about twice, in order to know the whole apparent breadth *dci*, inasmuch as, if you measure the length of *d i*, you will find it about twice that of *g h*.

Then the whole apparent breadth of the Earth, observed Eugenia, to a spectator at the Moon, must be about *two* angular degrees.

Yes, replied Franklyn; the angle at the Moon, spanned by the Earth's diameter, is found to be about two degrees wide, both by the above method of computation, only performed with many niceties; and another, still more accurate, but which it is needless to specify at present.

What you mean by that angle being two degrees wide, said Isabel interrogatively, is, that if its point *m* were laid at the centre of a circle divided into 360 equal parts, the two sides would take up *two* of those divisions between them?

Exactly; or, which is the same thing, the angle itself would take up two of the angles formed by rays to each of those 360 points of division.

How many of those divisions, or angles, would the *Moon*'s breadth, apparent *to us*, take up? inquired the Colonel.

That is what I was just going to state, replied Franklyn. If we bent a piece of fine straight *wire* into the form of a V or angle; then, bringing the peak to our eye, if we closed the two legs until, looking along one, we just saw the top of the Moon, and along the other we just saw the bottom; the angle formed by these two legs would measure the apparent length, or breadth, which is the same, of the Moon to us. If we now laid the peak of this V-shaped wire to the centre of a circle divided into 360 equal parts, the legs would take up only about half a degree. But I must observe here, that the Moon's breadth will appear greater or less to us, and the Earth's breadth greater or less to a spectator at the Moon, according as the distance between these bodies, which is not always the same, diminishes or increases. The breadth of neither, however, is at any time much different from what I have stated.

Well; but now to find the *actual* length of the Moon's diameter! said Eugenia.

That is a matter of little difficulty, after all the preceding computation, answered Franklyn slightly raising his eyebrows. We have found that the apparent breadth of the Earth, to a spectator at the Moon, is two degrees; or, which is the same thing, that if the said spectator were transplanted hither, and the Earth, or a sphere the same size, transplanted thither, its apparent breadth to the spectator here would be two degrees. But, we have also found, that the apparent breadth of the Moon, to a spectator here, is half a degree. Consequently, to a spectator here, the Earth, at the Moon's place, would appear *four* times as broad as the Moon at its own place. Hence the Moon can *really* be but one-fourth as broad as the Earth; or, at the same distance, it would not appear to be so. But the breadth of a sphere is the length of its *diameter;* and, therefore, the length of the Moon's diameter can be but one-fourth that of the Earth, or about 2000 miles.

We have found it, indeed! cried Isabel somewhat like the hatchet-finder's assistant in the fable.

It is indeed very wonderful! said Eugenia; nor could I have imagined the possibility of calculating the size of a body at such a vast distance as the Moon, with which we have no medium of communication.

Such is the energy of Human Reason!—You perceive that, in order to measure the diameter of the Moon, we have no need of Bishop Wilkins's *flying chariot*, which this enthusiastic philosopher, though by no means unsound divine, proposed for making discoveries in that luminary; and the construction of which, alone, was found to be a matter of some difficulty. By the illimitable flight of *mind* it is that we scale the heavens, taking the Earth as our vantage-ground, and soar higher and higher, from Moon to Sun, from Sun to Planet, till at length, as the ancient poet says,—

"With our lofty brows we strike against the stars."

Can we measure the *Sun*'s diameter in the same way? said the Colonel.

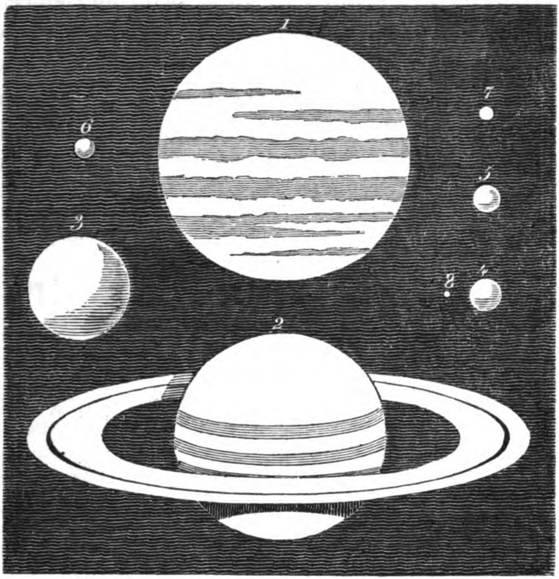
Yes: what should prevent us? Nay, the diameters of the planets also. But, I am afraid we should scarcely have time to conclude the subject this evening; and, therefore, perhaps we had better not commence it. Besides, if my senses do not deceive me, a whole bevy of bright-eyed visitors are approaching; and, it is to these "wandering stars" our attention must now be directed.

Franklyn was right. In one moment, the "Bird-cage" was as full as it could hold of pretty faces and prattle; ribands, sashes, plumes, kerchiefs, flounces, and tassels, rustled together in beautiful confusion; and, moreover, the variety of intermingling voices rendered all so unintelligible, that you would have thought a flock of Brazilian paroquets had migrated to England. Our Academician, as he stood somewhat apart, listening with a smile between Cynicism and good humour to the joyous sweet din of so many female voices talking in joyful concert, hummed to himself, unheard and unnoticed, the celebrated roundelay,—

> "O happy! happy! happy! happy Fair!
> Your eyes are loadstars, and your tongues' sweet air,
> More tunable than lark to shepherd's ear,
> When wheat is green and hawthorn-buds appear!"

And, laying a particular emphasis on a *certain* word in the second of these lines, he continued to hum them while he could do so without detection.

It is almost needless to add, there was an end to all philosophical conversation for that Evening.



EVENING SIXTH.

The next Evening, in the same place, the same Party, exclusive of the *paroquets*, were assembled. After some desultory conversation, Franklyn, drawing out a pocket-book, took from it a leaf of vellum, on which Isabel, glancing archly, thought she perceived some "astrological characters."

If you had called them *Arabic*, said Franklyn, you would have been nearly right; for they are chiefly *numbers*, of that form or shape introduced, if not invented, by the Arabian mathematicians. But I see your object: you have not forgotten Sidrophel, and wish to make me out an occult philosopher. However, a truce with your badinage for a few minutes; do not think me unreasonable in asking you to be rational for so long; we must intermingle the serious with the gay: as the old rhyme goes,

> "Every white will have its black,
> And every sweete its sowre."

We have relished your "sweete," and now you must sip a little of my "sowre."

Do not call it sour! exclaimed Eugenia. Can you forget what Milton says of Philosophy?

Franklyn repeated in answer:

> "How charming is divine Philosophy!
> Not harsh and crabbed as dull fools suppose,
> But musical as is Apollo's lute,
> And a perpetual feast of nectar'd sweets!"

Here is a little Table, in which I have set down the lengths of the diameters of all those heavenly bodies comprehended in our Solar System, as well as their lengths, compared with that of the *Earth*. You may copy it into your *Albums*, as a kind of relief to the poetry:

Diameter of		Miles.	Times diam. of Earth.
Sun .	is equal to	888,000	or 111
1. Jupiter .	. . .	88,000	. 11
2. Saturn .	. . .	80,000	. 10
3. Georgium Sidus	. .	32,000	. $4\frac{1}{4}$
5. Venus .	. . .	7,000	. $\frac{9}{10}$
6. Mars .	. . .	6,400	. $\frac{4}{5}$
7. Mercury .	. . .	3,200	. $\frac{2}{5}$
8. Moon .	. . .	2,000	. $\frac{1}{4}$

[The numbers 1, 2, 3, &c. refer to Engraving p. 119, which shews the rotation sizes of these bodies; and in which the Earth is numbered 4.]

Remember that none of these lengths are given as exact, though sufficiently so for us. I prefer keeping to *round* numbers as near as possible, because they are, in the first place, more easily *retained;* and, in the second, more easily *compared* one with another. Some Astronomers make the diameter of the Sun almost 5000 miles less; that of the Moon 1180 miles more; that of Venus nearly as long as the Earth's, which they make but 7,911 miles; that of Mars 2000 miles less than above stated. With regard to the four newly discovered planets, there is a great diversity of opinion, arising from the great distances and small magnitudes of those bodies, which render the computation we have just gone through very liable to error as applied to them. Dr. Herschel supposes that the diameter of the largest is not more than 200 miles; and it is generally agreed that *Vesta* is not 250.

But Juno's diameter is estimated by Schroeter at 1400 miles; that of Ceres at 1600; and that of Pallas at 2000, instead of *eighty* miles by Herschel.

I have here likewise a second Table, in which the magnitudes of the *spheres*, or globular masses, of the Sun, Moon, and principal planets, compared with that of the Earth, are registered. But before I show it you, I must have you calculate some of these magnitudes yourselves, in order to imprint the method I have already explained on your memories.—Reginald, how many times the size of the Earth is the planet *Saturn?*

Reginald. Saturn must be 10 times the size of the Earth, as his diameter is ten times the Earth's diameter. No—no—no! I remember what you said about my head and the apple!—I must say, 10 times 10 is 100, and 10 times 100 is 1000; therefore the *sphere* of Saturn is 1000 times as large as the sphere of the Earth.

Franklyn to Isabel. Miss Anaxagoras, will your philosophyship have the kindness to tell me what the size of that fiery-eyed, flame-coloured planet, just towards your left hand, is? Mars; you will always be able to recognize the God of Battles by his sanguine hue.

Isabel (looking into the Table of diameters). What am I to do with this little comical figure here, a minikin 4 and 5 with a line between them?

Franklyn. That is called a *fraction*, Miss

Anaxagoras; it is the fraction, or broken number, *four-fifths*, Miss Anaxagoras; by which your philosophyship will be so good as to understand that it expresses *four* out of five equal parts into which any thing is divided. Thus, if I divide this apple into five equal slices, each would be a fifth part of the whole apple, and four of them taken together would be four fifth-parts, or four-fifths, of the whole apple. Again: if the diameter of the Earth be divided into 5 equal parts, each will be a fifth of the whole; and four of these taken together will be four-fifths of the whole diameter. In order then to express that the diameter of Mars is in length four-fifths of the Earth's diameter, we draw a short line —, place a 5 below it, to express that the Earth's diameter is supposed to be divided into 5 equal parts, and a 4 above it, to express that there are 4 of these equal parts in the diameter of Mars: the whole "little comical figure," $\frac{4}{5}$, will thus express very neatly four-fifths of the Earth's diameter. To illustrate this by numbers: the Earth's diameter being taken at 8000 miles, and divided into 5 equal parts, each of these, or one-fifth of the whole, will be 1600 miles. Now, four of these together will be 4 times 1600, or 6400 miles, which we have seen is the diameter of Mars; consequently, the fraction $\frac{4}{5}$ expresses what part of the Earth's diameter the diameter of Mars is.

Isabel. But I am just as far as ever from knowing how to compute the size of the planet;

for this odious little fraction, clearly as you have explained it, puts me out.

Franklyn. I guessed it would do so; but, listen.—Mars's diameter containing 4 of those equal parts, and the Earth's 5, Mars's diameter must be to the Earth's as 4 is to 5: But, in order to find the proportion of two spheres, when we have two numbers expressing that of their diameters, we have only, as before, (page 107.) to multiply each of these numbers *twice* by itself, and the resulting numbers will give the proportion of the spheres. Thus, in the present instance: say 4 times 4 is 16, and 4 times 16 is 64; likewise say 5 times 5 is 25, and 5 times 25 is 125: therefore the spheres, whose diameters are as 4 to 5, are themselves as 64 to 125. Now 64 is not much more than half 125; consequently the sphere of Mars must be about half the sphere of the Earth in size.

Let us have another example of this kind, for the sake of practice.—There! glimmering faintly in the West, as she begins her placid reign, "in dim suffusion veiled,"

> "There Venus smiles o'er the blue Heavens afar,
> The Lover's cynosure! the Evening Star!"

And Eugenia, who contemplates this beauty of the skies with as much delight and satisfaction as a beauty of the earth ever contemplated herself, must tell me her dimensions as accurately as a sculptor would measure the Venus de' Medici.

Eugenia. You must assist me then in the Table of diameters; I suppose that fraction opposite Venus means *nine-tenths;* and expresses by the 10 underneath, that the Earth's diameter is supposed to be divided into 10 equal parts, and by the 9 above, that Venus's diameter is equal to 9 of those tenth-parts?

Franklyn. Perfectly right.

Eugenia. The diameter of Venus must therefore be to the diameter of the Earth as 9 to 10. So, following the rule you gave us, I say: 9 times 9 is 81, and 9 times 81 is 729; also, 10 times 10 is 100, and 10 times 100 is 1000; therefore the sphere of Venus is to the sphere of the Earth as 729 to 1000. But—but—I do not see how this tells me the size of Venus?

Franklyn. If you understood a little more of *Fractions*, it would tell you to a nicety. However, knowing only as much of them as I have taught you this evening, you see that the sphere of Venus is *less* than that of the Earth in the proportion of 729 to 1000. Now, 729 is considerably greater than 500, which is the half of a thousand; but it is a little less than 750, which is three-quarters of 1000: Consequently, the sphere of Venus is considerably greater than half, and only a little less than three-quarters, that of the Earth.

Eugenia. How useful those same little comical figures are!—till now I thought them only of use to puzzle and stupify.

Franklyn. They are precisely the most useful instrument of calculation to which Man ever set his hand; and in Science he might a great deal better want *both* his hands than a knowledge of Fractions. With all his genius, Newton could scarcely have written a page of his PRINCIPIA without their assistance, direct or indirect; if you thoroughly understood them, you need hardly understand any other rule in Arithmetic. So much for their utility!

Eugenia. How should I proceed to understand them thoroughly?—What you have said renders me very anxious to do so.

Franklyn. Learn GEOMETRY!—I can give you no shorter recipe.

Eugenia. I? a girl! so *masculine* a study!

Franklyn. Why, you learn to *ride*, or I am mistaken? And if that be not as "masculine a study," I am mistaken still more lamentably! Such objections are, to give them no harder name, marvellously *old-fashioned.* To be sure, you ride in a *side-saddle*, and amble or canter, where *we* gallop. Well! I do not ask you to study GEOMETRY *like us;* study it in your own way, as modestly and as moderately as is suitable to your sex; but *study it.* Believe me, that exercise will invigorate your mental, as much as the other will your corporeal system. And if the argument, or prejudice rather, that women are too feeble-minded to engage with success in the study, have any truth, I answer: for this very reason, let them by all means engage in the study—to strengthen their feeble-mindedness*. Besides, who wishes to see them female Archimedes or Newtons? Not *I!* though an advocate for their studying Geometry. Neither I, however, nor any unbigoted man wishes to see them female automata or nonentities. Perhaps, indeed, they themselves had rather remain so,—and I have nothing more to say on the subject.—Here is the second Table:

The Sphere of	The Sun is	1,367,031	times the Sphere of the Earth.
	Jupiter .	1281	. . . . .
	Saturn . .	995	. . . . .
	Georgium Sidus .	80	. . . . .
	Venus . .	$\frac{3}{4}$ (three-fourths)	. .
	Mars . .	$\frac{1}{2}$ (one-half)	. . .
	Mercury . .	$\frac{1}{15}$ (one-fifteenth)	. .
	The Moon . .	$\frac{1}{64}$ (one-sixty-fourth)	. .

In this Table also, remember that the magnitudes stated are not given as exact; and that they will vary according to the different estimates which different Astronomers make of the diameters, as before stated. For example, the sphere of the Moon is said to be $\frac{1}{49}$, or one *forty-ninth* as large

* On this subject Plato seems to have had much more liberal opinions than our modern *philosophers.* In his Republic he explicitly asserts, "There is no natural difference between the sexes, but in point of bodily strength; the exercises of their *minds* should therefore be *alike.*"—See Book V.

as the Earth's, instead of one *sixty-fourth*. However, this Table is sufficient to give you a general notion of the relative magnitudes of the Sun, Moon, Planets, and Earth.

These Tables will be most convenient when transferred to our pocketbooks, said the Colonel. We shall then, at a single glance, be able to see the proportional magnitudes of those interesting spheres which, as you say, compose our Solar System.

Yes, said Franklyn; and not only the proportional magnitudes of these *spheres*, but the actual lengths, in English miles, of their *diameters*. You should however commit them to your memories as well as to your pocketbooks.

I shall certainly do so! exclaimed Isabel. It will be a very pleasant task to get them by heart,—especially (continued she, half aside,) the little *fantoccini* figures.

Since you approve of these Tables so much, then, said Franklyn, what think you of a *third*, containing the respective *distances* of the Sun, Moon, and Planets, from the Earth?

You would have thought he had requested each of the Party to accept, in Othello's phrase,

> "A world of one entire and perfect chrysolite;"

in other terms, that he had offered to give each person, in the hand, one of those little golden spheres, as Isabel called them, which they so much admired, to do what they pleased with; all expressed such anxiety to possess the inestimable Tablet.

Well then, here it is, said he; but pray do not any of you *eat* it—as Swift tells us the mathematical students of Laputa did their Propositions and Demonstrations, swallowing them when written with cephalic tincture upon wafers, by way of devouring knowledge in the most practical and compendious manner.

Dist. from the Earth of	The Sun	is	96	millions of miles.
	Jupiter	.	412	. . .
	Saturn	.	825	. . .
	Georgium Sidus		1650	. . .
	Venus	.	27	. . .
	Mars	.	39	. . .
	Mercury	.	59	. . .
	The Moon	.	240	thousand miles.

This Table, like the former, you will recollect, is not given as minutely accurate; the nearest *round number* to the one generally received as true, is registered as the distance of each heavenly body; such being most convenient for our purposes.

Ninety-six millions of miles! exclaimed Reginald. No wonder for the Sun, large as it is, to appear so little!

I can hardly conceive a distance so great, said Isabel.

Perhaps it will assist your imagination to state it in another form? said Franklyn. Ninety-six millions of miles is about equal to *twelve thousand* diameters of the Earth; as appears by dividing 96,000,000 by 8,000, the number of miles in the Earth's diameter. Or thus:

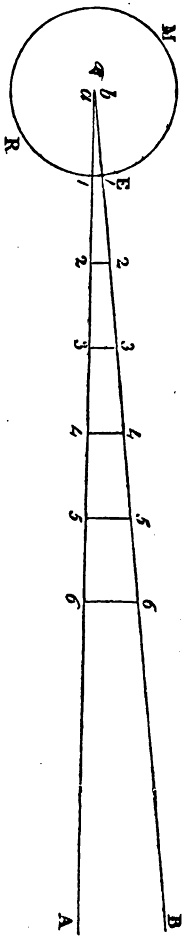
You have some idea of the velocity of a ball shot out of a cannon; it usually travels at the rate of about 8 miles in a minute. Now if a cannon were pointed at the Sun, and if it were possible that the Earth could stand still on its axis while the engine was being discharged; and if, moreover, the ball could go on in a straight line at the same rate of 8 miles a minute, until it reached the Sun; it would not hit that luminary for upwards of *twenty years!*

Let me see that, said the Colonel. 8 miles a minute is nearly 480 miles in 60 minutes, or an hour.

Say 500 for shortness, interrupted Franklyn. Then, 500 in one hour is 12,000 in 24 hours, or a day; but 8000 times 12,000 is just 96 millions; consequently, the ball must be 8000 days in reaching the Sun. As there are 365 days, however, in a year, 8000 days will be nearly equal to 22 years.

Most wonderful! But how is it *proved* that the Sun is at this enormous distance?

Why, as Reginald says, answered Franklyn; having already proved the Sun to be such an enormous body, it follows necessarily that he *must* be at an enormous distance, to *appear* so little as he does in the sky. But you may cry out indignantly, as Lady Pliant to Mellefont, in the Comedy,



"Fiddle, faddle! don't tell me of this and that, and every thing in the world, but give me *mathemacular* demonstration." Well, here is "mathemacular demonstration:"

We have shown (page 115.) that the apparent diameter of the Moon may be measured by an angular piece of wire; in like manner the apparent diameter of the Sun may be measured; and it will be found nearly of the same size as that of the sister luminary, viz. something more than half a degree in width. Very good. Now suppose an *eye* at C, the centre of the earth, as it is here delineated, and suppose C *a*, C *b*, the two legs of the wire, one of which points to the top of the Sun, and the other to the bottom, thus measuring the apparent width of that body. Continuing the direction of these legs in the lines CA, CB, let us suppose them to reach the top and bottom of the Sun at a great distance. At E the little arch of the meridian MER, between these lines, will consequently be something more than half a degree of the circle MER; but half a degree of the terrestrial meridian is, as we have seen, (page 44.) about 35 miles. Repeat the radius of the Earth on each of the lines CA, CB, as from 1 to 2, 2 to 3, 3 to 4; and, if you measure the breadths between 2 and 2, 3 and 3, 4 and 4, 5 and 5, 6 and 6, you will find them respectively twice, thrice, four, five, and six times, the breadth between 1 and 1; that is, they will be respectively 70, 105, 140, 175, and 210 miles,—increasing by 35 miles successively. Proceeding in this manner, at the twenty-four thousandth place, or after we had repeated the radius of the earth 24,000 times from C on the lines CA and CB, the breadth between those lines would be 24,000 times 35, or 840,000 miles, which is nearly the breadth of the Sun, as you will find in your Table of diameters. Hence, at this place, or distance, the Sun's diameter would about fit in between the lines CA and CB, and therefore would appear to an eye at the centre of the earth to span an angle of about half a degree; which proves that the Sun must be about this distance from the Earth; namely, 24,000 times the terrestrial radius, or 96,000,000 miles. So you see we have found out this too!

And are the distances of the Moon and Planets calculated in the same manner? inquired Eugenia.

Yes, they may be so; but I need hardly tell you that the method is a very rough one, and therefore only suitable for the purpose of elementary instruction. For the Moon, if we repeated the terrestrial radius on the lines CA and CB about 60 times, the breadth at the last place would be 60 times 35, or 2100 miles, which is about the Moon's diameter. Hence, this luminary if distant about 60 times the Earth's radius, or 240,000 miles, would about fit in between those lines; and therefore her diameter would appear to be about half a degree in breadth, if viewed from the Earth's centre. Wherefore, as it *does* appear to be about this breadth, her distance must be about 240,000 miles.

Now Isabel must tell me how many times more distant the Sun is than the Moon?

I am so bad an arithmetician! said Isabel.

As most young ladies are! observed the remorseless Academician. For the very purpose of exercising you in that most necessary Art, I put the question; let us, in this way, render our astronomical *conversaziones*, in some measure, subservient to your general improvement. Come! no refusal: How many times is 60 contained in 24,000?

I must divide 24,000 by 60, muttered she, doing the *sum* upon Franklyn's tablets, thus:

$$\begin{array}{r} 60)24000 \\ \hline 400 \end{array}$$

Four hundred is the answer!

Then is the Sun 400 times as far as the Moon, said Franklyn, he being 2400, and she being only 60 times the Earth's radius distant from us.—By the by, there she is: what a beautiful object! Let us descend into the orchard:

> "Cynthia checks her dragon yoke
> Gently o'er the accustomed oak,"

and beneath its shadow, let us in silence—

> "Walk unseen
> On the dry smooth-shaven green,
> To behold the wandering Moon
> Riding near her highest noon,
> Like one that hath been led astray
> Through the heaven's wide pathless way,
> And oft, as if her head she bowed,
> Stooping through a fleecy cloud."

They descended by one of the darksome paths which led down through the shrubbery behind the arbour, and opened on a "dry smooth-shaven green," surrounded by lofty trees, over which Cynthia was now, as the poet beautifully describes her, "checking her dragon yoke."

After some minutes' observance of the law proposed by our Academician, and which were employed by all in speechless admiration, he was himself the first to break it by asking—Whether it was not a very natural belief, that the tranquil sphere of glory they beheld was a fit mansion for the souls of the blest?

All replied in the affirmative, and Eugenia said, she could hardly forgive Ariosto for making it the receptacle of so many ludicrous and contemptible things, such as the lost wits of poets, &c.

Poetical enthusiasm is so apt to be kindled by the splendid light of the Moon, that from thence, I suppose, originated the notion of her exhaling, as it were, the brains of a bard through the fissures of his cranium—

> "Skull
> That's empty, when the moon is full;*

but she probably returns him, in the shape of her dewy influence so much spoken of, quite as much rationality as she runs away with. However this may be, the quiet beauty of her appearance is so prepossessing, that she has long been devoted to Philosophers as their especial paradise; than which no region can be imagined better suited to their love of repose and contemplation, by reason of its apparent serenity. Nay, surveyors of the Moon, such as Hevelius and Schroeter, have gone so far as to subdivide it into veritable Elysian Fields, and to set up bona fide *landmarks*, in order that every resident should be secured in quiet possession of his little solitude. A good way this to make these philosophers amends for the poverty and perturbation they have usually had to endure through life.

Each is now a petty king in his own dominions, and we are to suppose that the last wish of Plato's life is finally accomplished—to see "either kings philosophers, or philosophers kings." If the community exist, there can be no doubt but that it enjoys as perfect and happy a government, as Plato fondly judges it would, under such favourable circumstances; the only doubt is, whether it does exist at all. There *: do you observe a remarkable roundish spot just about the centre of the Moon, only a little to the left (1)? that is said to be the lunar residence of *Ptolemy*, an Egyptian Astronomer, who flourished in the second century, and published what he called the "Great System," and which the Arabian version translates, *Al Magest*. This Great System, also denominated the *Ptolemaic*, although a *great system of errors*, placing the Earth in the centre, round which the Sun, Moon, and Planets were supposed to revolve; yet as it was the first regular Treatise on Astronomy, perhaps entitles its compiler to his central position and very ample possessions in the lunar paradise. A little beneath him, in a spot of about the same size (2), Regiomontanus, (by his unambitious parents simply baptized *John Muller*) a German Astronomer, who while on earth was particularly devoted in his attentions to the Moon, now cultivates her *soil*, instead of her *acquaintance*. Several other philosophers,

* See Frontispiece.

who made discoveries on her globe, though perhaps they had not an acre of land on this, have taken due possession in their own names. Many more also, who were not so familiar with her geography as these, but were nevertheless greater Astronomers, such as Newton, Kepler, &c.; as well as some philosophers who were not astronomers, such as Plutarch, Seneca, &c.; and a few who were neither astronomers *nor* philosophers, but Heathen Gods, Catholic Saints, or Poets, such as Hercules, Saint Catherine, Schiller, &c.; all these have their respective *appanages* on the lunar surface, which has at least been portioned out for the settlers' characterized by their names, and it is their own faults if they have not migrated thither.

To whom does that vast circular district, about the middle of the right-hand upper quadrant (3), belong? inquired one of the party.

That?—That, you must know, is the lunar *Black Sea*, otherwise denominated the *Sea of Serenity*, over which its border kings, Pliny, Maraldi, &c. hold a divided sway, just as the Grand Signor and Russian Czar do with respect to the terrestrial Euxine,—only we are to hope more amicably.

What, then! inquired another, are there *Seas* in the Moon?

Look at the other side of the disc, said Franklyn; it is occupied almost from top to bottom with immense continuous spots, or rather spaces of darkness. What do you think these are? Observe that large one, in the left-hand upper quadrant, nearly corresponding with the Black Sea, except that it is a little higher and more circular: that is named the *Sea of Showers* (4). All the remainder of this continuous spot or space (5), enjoys a very sublime title—the *Ocean of Storms;* all but the lowermost parts, which are divided into the *Sea of Moisture* to the left (6), and the *Sea of Clouds* to the right (7), nearest the central line from top to bottom. Stretching across the top of the *disc* (8), you may perceive the *Hyperborean Sea*, or *Sea of Cold*, answering to our Frozen Sea. On the western, or right side of the disc, there is a fainter and lesser, but somewhat similar, expanse of darkness. That part adjoining the Black Sea is denominated the *Sea of Tranquillity* (9), exclusive of its most western border, which is only considered as a sort of *lake*, and has a kindred name—the *Lake of Sleep* (10). More western yet than this lake, but disjoined from it (11), is a very remarkable oval spot, called the *Lake of Mæotis*, or *Crisian Sea*, the lunar *Sea of Azof*. Immediately below the Crisian Sea, in the remaining quadrant of the disc (12), lies the *Sea of Fertility* or *Caspian;* and to the left or east of this, at the other side of that bright ridge (13), is the *Sea of Nectar*, which forms the very lowermost portion of the whole continuous expanse of darkness on this side. There are, besides, a great many lakes, bays, &c.; some with beautiful names, such as the *Lake of Dreams*, the *Bay of Rainbows*, the *Bay of Dew;* and some with ominous ones, such as the *Lake of Death*, the *Lake of Fogs*, &c.

It is very extraordinary, observed Eugenia, that if the spots you point out be in reality seas or lakes, they should appear so dark even when the moon is brightest. One would think that their surfaces ought rather to look like immense glittering mirrors, and have the same glassy appearance as water has upon earth.

The truth is, replied Franklyn, that, notwithstanding the poetry which has been expended in naming them, they are *not* seas, but hollow capacities, such as would deform the rotundity of our globe, if the water upon its surface were annihilated. This, at least, is the more probable opinion, for several reasons. First, they exhibit all those shades and varieties of light which cavities and uneven surfaces ought to exhibit. Secondly, although a very small *atmosphere* has been observed to surround the moon, no such changes have been remarked in it as would arise from clouds and vapors; from which it is naturally to be inferred, that no considerable surface of water exists from which clouds or vapors could be exhaled, or drawn up by heat into her atmosphere, as we see they are in ours. Thirdly, when the curved line which separates the light from the dark part of her disc (thence called the *circle of light and darkness*), passed over any of these large spots, it would *there* exhibit a smooth, unindented curve, if the surface of the spot were a fluid; but this is never found to be the case, and therefore we conclude there can be no great quantity of fluid in that place.

But even if there were, replied Isabel, why should the curve passing over it appear "smooth and unindented?" Are there not *waves* on our lakes, and seas, and oceans?

Yes, answered Franklyn; but do you think we could distinguish them at a distance of 240,000 miles? How insignificant in height are the most terrific of our waves, at the Cape, or in the most tumultuous ocean, when compared with the hills upon land! Why, the most stupendous billows are mere hillocks to a respectable mountain! It is only our terror which lends them their sublimity. Consider the land-surface of our globe, with all its mountains and valleys, as a fluid mass of earth just stiffened into permanent waves and furrows; is not the sea-surface of our globe smoothness and placidity itself, in comparison? In like manner, the firm surface of the lunar globe is rugged in comparison to the fluid; and at such a distance the latter would appear without a wrinkle where the circle of light and darkness passes over it. From her deficiency in water originates the arid, sandy nature of her soil; and the probable supposition, that if there be any philosophers inhabitants of her sphere, Pythagoreans make few of the number.

Why *Pythagoreans?* demanded Eugenia, who was something of a mythologist.

Because, imitating the great Founder of their Sect, who, by the by, in this seems himself to have imitated the Brahmins of India, from whom he imbibed several of his doctrines, they abstained from eating flesh, and lived almost entirely on vegetables, which must be too rare and dear in the Moon, on account of her peculiar soil and atmosphere.

That reminds me, said the Colonel, of something I had nearly forgotten. How is it discoverable that the Moon has *any* atmosphere?

By means of very refined telescopic observations, which I could hardly explain to your complete satisfaction at present. However, you know that our *twilight* is produced by the sun's rays being reflected from the particles of our atmosphere after that luminary has descended; now, a reflection of this kind was observed by Schroeter to take place at the Moon, from whence he concluded the existence of a lunar atmosphere. It is indeed very small; not much more than 5700 feet high, it is said, where it is of perceptible density, and this is only about half as high again as Snowdon in Wales, which is 3570. Very nice computations show that it is full 1000 times thinner, or rarer, than our atmosphere; so that, like Manfred,

——"to breathe
The difficult air on the iced mountain's top,"

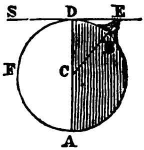
must try the lungs of a chamois-hunting philosopher amongst the lunar Alps and Apennines.

Are you about to create mountains in the Moon, as you did seas, only for the pleasure of annihilating them? said Mrs. St. George.

No; there *are* mountains in the Moon, and volcanoes too. Do you not observe how jagged and saw-like the edges of her disc are? Is not this ocular demonstration that her surface is uneven, consisting of alternate hill and valley, like the globe we inherit? Her cavities, to be sure, might assist in producing this appearance, by means of their unenlightened parts; but they could not wholly account for it. Besides, with a powerful glass we may almost always detect *bright* spots on the *dark* portion of her disc; and what can these be but the tops of mountains, illuminated by the Sun, while their bases are in darkness; just as the Peak of Teneriffe or Chimboraço is seen at a great distance, tipt with light, its feet and sides remaining yet invisible?

Yes, said the Colonel, I have been a witness of that beautiful phenomenon; in my last voyage to the Azores. At a distance of 50 miles we beheld the Peak of Pico, like a bright spot or cloud, in the horizon, while it was yet dark night all over the island beneath. At our ship it was barely twilight.

The solar rays, or, as Milton expressively calls them, "long levelled rules of streaming light," were then, I suppose, just grazing the convex side of the globe, where your vessel moved, and fifty miles farther caught the top of Pico-peak. Look here, Reginald, continued Franklyn sketching a figure



to assist the boy's perplexed imagination. Conceive EB to be the mountain called the Peak, in the island of Pico, one of the Azores or Western Isles; and let EDS be a straight line drawn from the summit E, so as just to touch the round surface of our globe at D. Conceive also, that the vessel in which your Father sailed was at D, then the summit E would be just in his horizon EDS. Consequently, when the sun, rising at the eastern side of D, shot his first rays along the horizon, in the direction SDE, they would graze the earth at D, making twilight there, and tip the Peak at E, occasioning daybreak here also, while all below E to B remained as yet unenlightened. Indeed this phenomenon is, or may be, observed by every mountaineer who rises early to his labour. The foreheads of his native hills are crowned with light, whilst their feet are clothed in darkness. Even a lover, who is generally so much employed in adoring the splendor of his mistress's eyes, that he scarcely deigns to notice any other, might, if his serenade last long enough, observe the same glorious appearance. Romeo exclaims to Juliet:

> "Look, love! what envious streaks
> Do lace the severing clouds in yonder East:
> Night's candles are burnt out, and jocund Day
> *Stands tiptoe on the misty mountain tops."*

I wish, indeed, that Night had been careful enough to use torches instead of "candles" upon that occasion, but the imagery in the last line-and-half is ten thousand times as magnificent as morning itself could present us with. Day is personified as a bright Youth, standing tiptoe on the hill tops, while each successively brightens with the glory of his presence.

Does not Horatio allude to the same enchanting spectacle, said Eugenia, in those equally beautiful verses?

> "But, look! the Morn in russet mantle clad
> Walks o'er the dew of yon high Eastern hill."

Yes, replied Franklyn; except that perhaps the words "russet mantle" indicate an earlier hour than the epithet "jocund," which bespeaks the laughing splendour of Day himself. Milton, always emulative of Shakspeare, personifies the Goddess of Twilight in like manner, robing her as quakerly:

> "Thus Night oft see me in thy pale career,
> Till *civil-suited* Morn appear."

where "civil-suited" means gravely apparelled, and is equivalent to "russet-mantled." Now, if SDE were a solar ray, just grazing the top of the Moon's disc at D, it is manifest that if her convex surface were perfectly smooth and globular, the ray would pass on without touching it again; and that if the ray did touch it again, say at the point E, this point must be elevated above the circle DBA, or, in other words, this point must be the peak of lunar eminence, which has quite as good a right to the name *mountain*, as Chimboraço or any other on earth. To the Lunarian, therefore, (supposing the existence of such a being) at D, "civil-suited Morn" would appear at the peak E, if the Moon revolved like the Earth on an axis carrying the said mountain towards DS: and, after a little time, Day would "stand tiptoe on its misty top," as jocundly as on Pico-peak, or perhaps more so, as the lunar atmosphere is so clear and transpicuous.

And therefore, said the Colonel, why should not we perceive this phenomenon as well as the Lunarians, if our sight were strong enough in proportion to our greater distance?

"Get thee glass eyes," as Lear says to Gloster, replied Franklyn; in other words, look through a telescope. Dr. Herschel, Schroeter, and others, have frequently observed the phenomenon; and, what is more, have actually deduced from it the *height*, in bona fide English feet, of several lunar mountains.

Where will the audacity of human investigation stop? cried Eugenia with deep enthusiasm.

Where its *power* does, I suspect, answered Franklyn; and Heaven forbid that it should stop a pace short of that limit! Herschel's method of computation gave *half a mile* as the general height of the lunar mountains, which few or none exceeded. Schroeter's method, however, which is far more accurate, gives a very different result. Several of the mountains, those called *Leibnitz*, and *Deerfel*, for instance, appear to be more than *five miles* high, loftier by nearly one-fifth than Chimboraço, the loftiest of the Andes.

I believe the Himmaleh mountains in Thibet are about five miles high, observed the Colonel.

One of them, Dhawalagri, the highest upon earth, is rather more; Yamunatri, the next highest, is rather less, replied Franklyn. But if we take into consideration the relative sizes of the terrestrial and lunar globes, our loftiest mountains bear no comparison with those of the Moon. It is possible, therefore, that our globe appears to the Lunarian astronomers almost perfectly smooth, unless their telescopes be as large as the Thames tunnel.

How did Herschel, and that other man with the delightfully musical name, contrive to tell so exactly the height of these lunar mountains? inquired Isabel.

By comparing EC, the distance of the illuminated peak from the Moon's centre, with the Moon's radius, whose length is known. For example, if E C, observed through a telescope, appeared one *four-hundredth* part larger than C D; then, as we know C D is 2000 miles in length, and as one 400th part of 2000 is 5, E C must be five miles longer than C D or C B; which gives five miles for the length of E B, the height of the mountain *. This is but a very imperfect sketch of the method; indeed, it is wholly inadequate, except to give you a notion of its practicability. Learn a little Geometry, if you would learn much of any science.

But the *Volcanos*, said Isabel eagerly addressing the Philomath; I wish to know something about those huge *spit-fires*, if there be really any such things in the Moon. Must we learn geometry before we can learn this?

No, replied the imperturbable youth; it is only necessary you should learn how to observe by means of a telescope.

There!—said the girl raising the glass to her

* For the mathematical computation of the altitude of a Mountain in the Moon, see DARLEY'S GEOMETRICAL COMPANION, PROBLEM XXII.

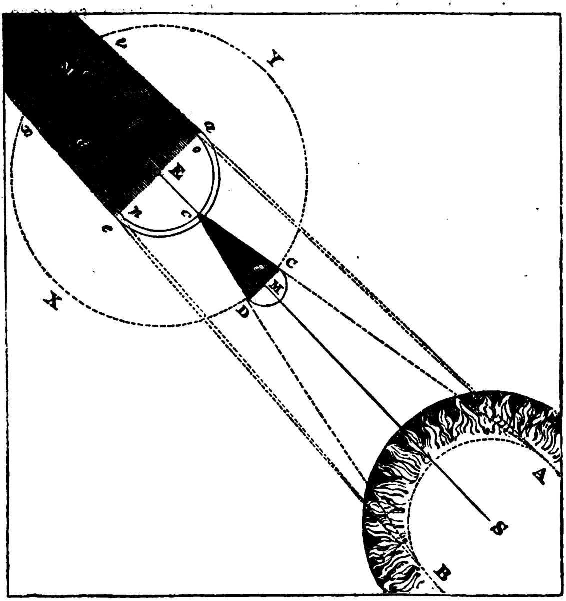
eye; in this difficult part of science I am an adept already. I observe the Moon now.

That is only *seeing* by means of a telescope, my good girl! said the hard-hearted Franklyn; it is not observing. Believe me, neither Herschel, nor "the man with the musical name," nor any one else, became a great astronomical observer in so great a hurry. It requires a long and a studious apprenticeship. Imperfections in the glass, changes in our atmosphere, changes in the lunar atmosphere, a variety of other causes, between this and the Moon, exist to distract and deceive the observer. Our friend Sidrophel, who mistook a *lantern* at the tail of a kite for a *planet*, and when the cord snapt,

> "Cried out—What horrible and fearful
> Portent is this, to see a star fall!"

Sidrophel, I say, is not the only stargazer on record, whose errors evince the difficulty of *taking an observation*, as it is technically expressed. To distinguish, for example, the light of a volcano from that of a sun-tipt hill, at so great a distance as we are from the Moon, requires an acuteness of vision and a delicacy of *eye*-judgment, which can be attained by long practice alone. When, indeed, a bright spot is discernible on the dark part of the Moon's disc, so far within the circle of light and darkness that it could not be occasioned by rays from the sun, we may fairly conclude this to be the crater of a burning mountain. Such spots are frequently observed. But if they be nearer that circle, it will frequently perplex the nicest power of observation to determine whether the spot be a crater or a sun-tipt peak, and frequently baffle it altogether.

Some desultory conversation upon the wonders they had heard of now ensued, as our Astronomers slowly quitted the orchard, much later than usual.



EVENING VII.

> " UNMUFFLE, ye faint stars! and thou, fair Moon,
> That wont'st to love the traveller's benison,
> Stoop thy pale visage through an amber cloud,
> And disinherit Chaos, that reigns here
> In double night of darkness and of shades!"

Thus exclaimed Franklyn, who was somewhat academically given to quotation, as he stood amidst his disciples, beneath a dim arcade formed by two ranks of tall larch-trees, thickened on each side with cypress, box, and acacia. Every eye watched the beautiful luminary, which was now struggling, almost hopelessly, to emerge from a sea of clouds which rolled over her face, like breakers over that of a drowning woman.

Mercy befriend her! said the Enthusiast for the moment, as it were, overcome by this image of distress,—she will never raise her head again!—stay!—There she floats on the blue Pacific of Heaven, after having safely cleft her way through the billowy ocean now behind her! There, she rides in her silver barge, lovelier and with far more splendour than Cleopatra on the Cydnus—

> "The Queen of Night! whose large command
> Rules all the seas and half the land,"

though, indeed, the cloudy sea threatened just now a most serious rebellion.

She is fully as pure and brilliant as we saw her last night. But how is this? said Eugenia; I see the very same spots on her visage, of the very same shape, and in the very same position, as before. Nay, now that I think of it, I have *always* seen these as they now appear. Does the Moon, when full, always present the same face to us?

Whether full or not, she always presents nearly the same face to us, though we cannot always see it, replied Franklyn.

Then, at all events, said Isabel smartly and not a little decidedly, here is *one* of the planets which does not revolve on an axis.

First and foremost, my Lady Sweet! replied our Cynic, the Moon is not a *planet*,—at least she is not one of the *primary* planets, which, I have already informed you, are but ten in number: she may, if you please, be called a *secondary* planet, as indeed she sometimes is; but her most usual title is, *a satellite*, because she accompanies the Earth in its course round the Sun.

Secondly: It is no proof that she does not turn on her own axis, because she always turns the same face to us.

No! said Isabel in great astonishment. Surely if she *did* turn on an axis, we should see her *all round?*

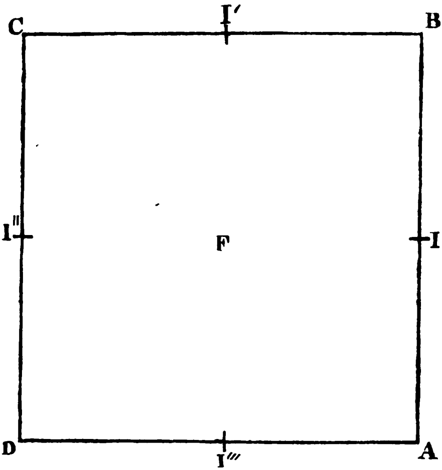
Indisputably. Ah! that you had read a little *Logic!*—that you had dipped but the forehead of your understanding into Watts, or Aldrich, not to speak of Burgersdicius, Peter Ramus, or Aristotle! You would then never have thought of arguing in such an inconsequential manner.—Prithee, turn thyself—turn thyself, unhappy Maiden! round about —quite round!

Isabel gravely obeyed, wheeling about quite round.

Now, continued Franklyn, we have seen you "all round;" but can you be so illogical by nature as to argue from this circumstance, that if we, standing here together, did *not* see you all round, but saw your face continually,—that therefore you cannot continually turn?

Why goodness! what else could Aristotle or Ignoramus, as you call him, think of arguing, with all the logic in the world! exclaimed Isabel.

O miserable girl! what will become of thee, if thou remainest in this state of unbelief and contumacy?—*Attendez, Mademoiselle!* said he more seriously. Face me. Now walk in a circle round



me, facing me all the time. Nay, do not twist your neck in that manner! face me with the whole front of your figure, continually.

I cannot, said she, unless I *turn myself* according as I walk round.

"Why, what a Pagan fair one is this! an Infidel!" quoth Franklyn. Yet, although you here find yourself *compelled* to turn continually, in order that I may continually see your face, you persist in denying that the Moon may, in like manner, continually show us her pale one, as she moves in a circle round the Earth!

Isabel was silent.

You see, Donzella! that it is very possible in this deceitful world, to keep the same face towards a person, yet continue to change all the while, said Diogenes the Younger. When you had walked a quarter of a circle round me, from I to I′, a line through your shoulders, which was in the direction AB at setting out, came into the direction CB, perpendicular to AB. This shows that you had been compelled to turn yourself a quarter round; for, if you had not turned, the line through your shoulders would, at I′, have been in its first direction A B. When you had walked half of the circle round, and stood at I″, the line DC, through your shoulders, became perpendicular to CB, which shows that you had turned yourself round a quarter more. In fact, your left shoulder, which was opposite my right at setting out, was opposite my left when you came to I″ (supposing me *not* to have turned); so that you must have gradually turned yourself half round during the interval. If you had not turned, your left shoulder would at I″ have been still opposite my right, and we should have stood back to back. When you had walked three-quarters round the circle, and stood at I‴, you must have turned yourself three-quarters round in order to face me there; and when you had walked completely round the circle, you yourself must have turned once completely round, in order to face me as at first.

Do you perfectly understand that, Reginald? said his father.

If he does not, subjoined Franklyn, lay your cane across his shoulders, in the direction of the line AB, and let him walk round the circle while you make an example of him.

Reginald, without perceiving the *equivoque* which Franklyn intended, took the cane by each end, and, stooping under it, brought it flat upon his shoulders. He then marched round the circle, keeping a full front and a steady eye on Franklyn all the time.

There! said the latter, you see how the cane gradually turns round as Reginald proceeds in the circus.—Now imagine a cane *ten thousand miles long* to be run through Cynthia's fair sides, as she is too round-shouldered for it to be laid at her back; this cane would twice turn itself about in the same manner as Reginald's did, while she proceeded in her course round the earth; and it would exactly have turned once completely about, when she had completely finished one course.

I never understood before how the Moon could always continue to present the same face to us, while she revolved about us, said the Colonel.

As the Moor says of his unhappy wife—"Sir, she can turn and turn, and yet go on!"—In about twenty-seven days she performs one entire circuit round the earth; and therefore in about the same time she must herself turn once round upon her axis. By this means she keeps her back perpetually unseen, facing about more and more as her circular progress tends to expose it. Recollect, however, that she does not always present to us *exactly* the same disc, as attentive observation with a good glass would soon discover. We sometimes see more of her eastern, sometimes more of her western side; she, as it were, *oscillates*, or swings about her axis, a little; and this balancing motion is called vibration or *libration* (from *libra*, a pair of scales). It evidently proceeds, not from a real vibration in herself, but from turning sometimes quicker, sometimes slower, on her axis, than she revolves round the Earth; thus exhibiting more of her eastern, or western cheek, as may happen. If Isabel, for example, were to have turned herself more than a quarter round, while she walked only an exact quarter of this circle about me, I should have seen more of her right cheek than at first; and more of her left if she were to have turned herself less than a quarter round. Other librations take place in the Moon, but the mention of this is sufficient.

I met the oddest word imaginable in an astronomical writer to-day, said Isabel. *Di-tchotomized.* He spoke of the Moon being *di-tchotomized.* What in the world could he mean by such a ridiculous term? Is it Russian?

No; Greek,—the most beautiful language ever uttered by mouth of Man: how much more so then when uttered by that of Woman! Forgive me, but your pronunciation alone makes it sound ridiculous. It is spelled *dichotomized,* and you pronounce the *ch* as if you were about to say *cheese;* pronounce it as if you were about to say *cot,* and however unintelligible the word may appear, it will not be unmusical. A body is said to be dichotomized when it is *divided* into two equal parts; from *dicha* twofold, and *temno* to cut. Hence, when the Moon is but half-full, and so is apparently cut through the middle, she is, in astronomical phrase, said to be *dichotomized.* I do not advocate the use of such terms, when we have simple equivalents for them in our own language: it is labour enough for a student to learn an abstruse science, without having to learn an abstruse vocabulary at the same time. I would, therefore, rather avoid these technicals in our discourses, but the present one comes very apropos to the subject I had not entirely concluded.

When the Moon, proceeded Franklyn, is exactly half-full, or dichotomized, the boundary of light and darkness, though circular on the actual surface of her globe, is apparently to us a straight line, the diameter of the visible disc. Now you are to understand that her course round the Earth is performed in a huge imaginary ring, to which this straight line is nearly *perpendicular*. Conceive a ring, whose radius is about 240,000 miles long, to surround the Earth at its centre; and conceive this ring to pass through the sides and centre of the Moon, so that the dichotomizing line shall be upright to the ring; you will then have a notion of the Moon's *orbit*, that is the orb-like circular path in which she revolves about the Earth. Being threaded, as it were, by this ring, she moves along it round the earth, in about 27 days 7 hours; while, in the same period, she turns once round upon a diameter of her sphere, namely, one almost upright to her orbit. This is her *axis*, and we may call its two extremities her *poles*.

Yes, the top and bottom of the dichotomizing line, said Isabel.

No; that line is not her axis, being only the *apparent* diameter of her *disc*. But if her sphere were *sliced* through that line, her true axis, the diameter of her *sphere*, on which she really turns, would lie in that slice or *section*, and be, as I have said, nearly upright to her orbit. Not being accurately so, however, her uppermost pole will lie a little below the top-edge of her disc, and we can thus see a little of her back, it may be said, behind the pole; but so little that we may consider this pole as the very *point* of her uppermost horn.

Her *equator*, then, remarked the Colonel, is just midway between her uppermost and lowermost points?

Yes, nearly so, replied Franklyn; and therefore is nearly coincident with the *plane of her orbit*, or the imaginary ring upon which we have supposed her strung,—as you might string a pearl on a silken thread.—By the by, recollecting this circumstance, you may often pretty accurately tell the line and direction of the Ecliptic, or *terrestrial* orbit, Zodiac, &c. in the heavens, when the Moon is visible. For I must inform you that the Moon's *apparent* path among the fixed stars is nearly that of the Sun; or in other words her orbit round the Earth is nearly in the same *flat* or plane as the Sun's apparent orbit round the Earth, or the Earth's *real* orbit round the Sun. Consequently, as her equator is coincident with the plane of her orbit, we have only to imagine a *belt* crossing her disc half way between the points of her horns; this will be in the direction of her equator, and therefore in the direction of the Sun's apparent path on the heavens, *i. e.* the Ecliptic.

Then, if she were *dichotomized*, said Eugenia, a line crossing her disc perpendicular to the dichotomizing line, would be in the direction of her equator and our ecliptic?

Nearly, as I said before. Strictly speaking, however, the Moon's orbit is not exactly in the same plane with the Earth's; half of it is on one side, and the other half on the other of the latter plane.

Have you never seen two *hoops* riveted together at two opposite points, so that one plays within the other?

Conceive the two apparent paths of the Sun and Moon on the heavens to be two invisible hoops riveted at two opposite points in the same manner; and conceive the latter turned on these pivots, so that its halves will be at different sides of the former, but only about ten times the Moon's diameter distant at the greatest breadth between the hoops; you will then have a more precise notion of the relative situation of the two apparent orbits. Now these rivets, or pivots, are technically called *Nodes*, the Latin for *Knots* (*nœuds*, you recollect, in French), because the orbits are as it were *knotted* in these points.

I perceive, said Isabel, the *nodes* are the points where the two paths *cross* each other.

Where they *appear* to cross each other, said Franklyn tapping her on the shoulder; for you know that the Sun's path is not a real one.

Well, then, at all events, retorted the lady, the nodes are those two points where the paths of the *Earth* and Moon cross each other.

"Still wide! far wide!" as Cordelia says to her crazy parent. The *paths* of the Earth and Moon seldom cross, whatever the *planes of their orbits* may do. By another pair of rings, continued Franklyn, I will endeavour to illustrate the truth of this matter. You have seen at the housekeeper's girdle a huge cut-steel ring, with several smaller running on it: Suppose a little ring, linked to a very large one in like manner. Suppose also that the little ring is so held that its *centre* should be in the rim of the large one; or, in other words, that about one half of it should be inside, and the other half outside the great ring. Moreover, suppose that the little ring did not lie as flat as it could on the large one, but that one half was raised somewhat above it, and the other depressed below it. Now, it is evident, that if a ball moved completely round the little ring, it would be for half its journey *above* the large one, and for the other half below it; while, in moving from above to below, or from below to above, it would pass through the plane or flat of the large one.

Yes; once inside and once outside the large ring, said Eugenia.

Very well. These points are the real nodes; and that through which the Moon gets above the ecliptic is called the *ascending* node, while that through which it goes below the ecliptic is called the *descending* node. The imaginary straight line joining the nodes is called the *line of the nodes.* However, to us who are in the centre of the Moon's orbit, and at such a distance from her, she appears not to revolve in a smaller circle *within* the concave surface of the heavens, but to tread that very surface itself, like the Sun, in an *ecliptic of her own,* inclined to his at a small angle (about ten times her breadth where broadest). The nodes, likewise, appear to be intersections of these two ecliptics, and the line of the nodes to pass across the whole heavens. This line, remember, is not fixed: the whole orbit of the Moon has a circular motion, by which the real line of the nodes is twirled about its middle point, on the plane of the Earth's orbit; and thus the line of the apparent nodes moves also, carrying these nodes round the Sun's apparent path in the heavens.

How singular! which way do they move? inquired Eugenia.

From east to west; that is, contrary to the order of the signs Aries, Taurus, &c. which run from west to east. Considering the movement of a body, *according* to the order of the signs, as *direct*, a movement *contrary* to the order of the signs may be denominated *retrograde* (from the Latin *retro*, back, and *gradus*, a step; whence retrogradation comes to mean, *stepping-back*). Hence the motion of the lunar nodes is retrograde; and these backsliders complete a whole revolution in about eighteen years and a half,—returning to the points of the solar ecliptic from which they first set out.

If these apparent nodes were real, that is, if the Moon's path actually crossed the Sun's, and that these two bodies happened to come together in one of the nodes, what a terrible crash there would be! said the Colonel.

Something like that which certain theorists imagine to have created the four new planets, Ceres, Vesta, Juno, and Pallas, said Franklyn. These are supposed to have originally formed but one large planet, which, either by internal commotion, or the external stroke of a *comet*, was split into quarters, and came " flying all abroad," in the shape of four little planetary fractions.

Franklyn, you are surely jesting! exclaimed all the party with one mouth.

That is more than the said theorists are, I can assure you. And, perhaps, when we consider a fact observed of these planets, that three of them, Ceres, Vesta, and Juno, pursue almost the very same course in the heavens, the said theory will derive a probability in our eyes, which at first we are not willing to grant it. 'Tis, indeed, a very sensible notion; a most rational opinion!

Here there was a dead pause for some moments, while the females drew breath; Franklyn looking very ambiguous.

And might not the Earth be destroyed in the same manner? exclaimed Isabel, pale with apprehension.

Unquestionably it *might;* either by an earthquake sufficiently powerful, or the thwack of a comet given with sufficient unction, replied Franklyn with provoking levity to this frightful question.

This, then, may be the second end of the World, which has been so often prognosticated? said the Colonel, who had faced death too often to fear it.

It *may* be so,—that is to say, of *our* world,—still with his usual composure replied the Tormentor.

But do you think it *will?* said Isabel determined to hear the worst.

"Will?" Oh! by no means; I never indulged such a speculation!

Intolerable! Why could you not give this answer at first? said Isabel angrily.

Merely because you did not ask your *last* question at *first*, returned Franklyn; I like to be categorical.—But, Colonel! you spoke of the Moon's path actually crossing the Sun's; this, you know, could not be, as the Sun's path is not real. However, one of the most singular phenomena in nature does occur from the *apparent* crossing of those paths,—I mean an *Eclipse*. Before the cause of these phenomena was understood, they were regarded with nearly as much apprehension by the whole *civilized* world, as our friends here expressed at the probability of the Earth being frittered into planets; or as the approach of a Comet occasioned some years ago in France, where several people lost their lives through the mere terror of losing them. In all ages they were considered as portentous, especially betokening the fall of empires, the defeat of armies, or the death of great personages. Even a poet of the last century but one, the most erudite of all his profession, countenances this superstition:

> " As when the Sun new risen
> Looks through the horizontal misty air
> Shorn of his beams; or from behind the Moon,
> *In dim eclipse,* disastrous twilight sheds
> On half the nations, and with fear of change
> *Perplexes monarchs.*" PARADISE LOST.

After all, observed Mrs. St. George, it was not very unreasonable to suppose that such preternatural darkness foreboded something of an extraordinary kind.

Unusual would be a better word than " preternatural," said Franklyn; inasmuch as an Eclipse is no more preternatural than the darkening of a room by placing a screen before a sconce-light upon the wall. But some remarkable coincidences between Eclipses and certain momentous disasters upon earth did confessedly take place, and form the best excuse for these ignorant fears and opinions. Thus, a Roman Calendar, of great antiquity, records that an Eclipse of the Sun happened on the very day when the foundations of Rome, " the Eternal City," were laid. About thirty years afterwards, there was a total eclipse of the Moon, and of the Assyrian Empire too, which was extinguished by the Babylonian. In the year 431 before Christ, an Eclipse of the Moon occurred simultaneously

"But men may construe things after their fashion,
Clean from the purpose of the things themselves."

Now hear how I will explain these phenomena; and if you still think proper to regard them as preternatural occurrences, you may take your place with the sages of antiquity, who believed the same things implicitly.

First, let us suppose that the Moon's apparent path on the heavens exactly coincided with that of the Sun; only that, as she is not so far from us as he, the former circle lay within the other, just as one ring may be within another, yet both have the same centre. Now if, on this hypothesis, both Sun and Moon set out from the same point, at the same time, with the same velocity, it is plain that the Moon, on account of her less distance, appearing of the same size as the Sun, we should never see the Sun from one end of time to the other.

A perpetual eclipse! said one.

Eternal darkness! said another.

Intense cold! said a third.

Dreadful!—dismal!—horrible!—intolerable!—ejaculated all together.

Nothing of the kind! said Franklyn composedly: not one of these things would come to pass as you imagine.

What! neither cold, darkness, nor eclipse, if the Moon was directly between us and the Sun?

No! certainly not, replied the stubborn Wrangler, —unless the solar rays were prevented by the lunar mass from reaching the terrestrial surface; in plainer terms, unless the Moon stopped the Sun-light from coming to Earth.

And pray would she *not* do so? demanded Isabel in a tone of pettishness.

She would if she could, I dare say, retorted he flippantly, for her sex has been always the fruitful source of mischief to mortals; but she could not, Serena! she could not, sweet Heroine of Hayley! Look you here: the Sun being directly behind the Moon, imagine rays to be drawn from all the points in the circumference of the Sun, to all the corresponding points in the circumference of the Moon; imagine those rays to proceed in these directions till they *met*,—which they would do, as the Moon is really smaller than the Sun,—what kind of a figure would be thus formed?

A sort of *spire* or *cone*, of which the Moon would be the base, and the point where the rays met the pinnacle, answered the Colonel.

Exactly; somewhat the shape of a *strawberry-pottle*, or just as if you laid the ends of several straight and equal rods of silver-wire in a circle round any globe, and then gathered in their other ends to a point. If you conceive all these wires lengthened *backwards* from this globe, each in its own straight line, a *larger* globe might be dropped into the cone at some distance behind the smaller;

and the wires being taken as rays from this larger, *it* may be considered to represent the Sun, while the other may stand for the Moon. Now, do you not perceive that it is only the interior of this cone between its pinnacle and the Moon, from which the Sun's direct rays are excluded?

Yes, that is plain, said Eugenia; the Moon's opaque substance prevents any rays from passing through her into the peaked chamber of the cone, but all outside of *that*,—all around the Sun himself, except that—what shall I call it?—

That *fool's-cap of darkness* placed on the Moon, suggested Franklyn; all except that, is as much exposed to the Sun's rays as ever. Hence, you see, the world would be neither cold, dark, nor in eclipse,—neither "dreadful, dismal, horrible, nor intolerable," except that little modicum of it within the cone, even though the Sun were perpetually hidden by the Moon as we have supposed. This, indeed, would be what astronomers call an *occultation* or *obscuration*, but not an *eclipse*. Thus when the Moon's disc floats over a fixed star so as to hide out the latter from sight, an occultation of the star ensues; but not an eclipse, inasmuch as we know that the star is too distant behind the Moon for her conical shadow to reach it. I grant, however, that though the Moon's perpetually blotting out the Sun's disc from our view, in such manner as above supposed, would not therefore deprive us of *his* light, it would most effectually deprive us of *her* *own;* for as she is an opaque body, and as her light is merely the reflection of his, if she perpetually stood between us and him, she could never reflect Sunlight hither, and therefore we should never have *Moonlight.* So far, indeed, the Earth would be a sufferer in point of illumination.

And of all earthly creatures, the *poets* would sympathize most keenly with her sufferings, observed Eugenia; for they would thus lose the darling object of their contemplation; they would no longer have this "Sun of the sleepless," as Byron fancifully calls her, to celebrate for her placid brilliancy and queen-like splendor.

Yes, replied Franklyn, but how many fine things would they not have to say of the *black Sun,* which they would behold instead of her! Such an object would have especially suited the gloomy genius of that poet whom you have mentioned.

A black Sun!

Ay, a black Sun, or at least a very *brown* one. Have you never observed the colour of the Moon in a solar eclipse? Is it not a deep bistre, or yellowish black?—If, then, she covered the whole disc of the Sun, should we not have the appearance of a dark-brown Sun moving across the sky, just as the gloriously bright one does at present?

But I thought you said that a perfect eclipse would *not* take place? observed Isabel.

True, and for that very reason the brown Sun would appear *blacker;* so that we should behold as it were an eternal miracle—brightness emanating from a black luminary!

This would be only an *appearance*, however, said the Colonel; as it would be the dark side of the Moon which we should mistake for the Sun's disc behind her, from which disc the brightness you speak of really emanated.

Precisely, answered Franklyn; the Sun would be, as it were, blotted out, and the Moon would be the blot which concealed him. You have never seen what is called a *transit* of one of the planets over the Sun's disc?

No; I hardly understand what it means.

The Latin verb *transeo*, which makes *transit* in the third person, means, I go over (from *trans* over, and *eo* I go); thus the admonitory exclamation,

> "*Sic transit gloria mundi!*
> So passes the glory of the world!"

Astronomers apply the word to a certain phenomenon, which does not often visibly occur in our system—the *passage* of a planet over the disc of the Sun. This is called the *transit* of the planet; but this is only, as the French say, *par excellence*, for the passage of *any* one object over *any* other may be denominated a transit with just as much propriety. Now, the planet Mercury passes over the disc of the Sun at intervals of a few years, but his mass is so small that these transits are not visible to the naked eye. Venus, however, whose transits are very far asunder, may be seen by the naked eye, when she passes over the Sun's disc, and then appears like a black spot upon an orb of gold. A transit of Mercury happened in the year 1822, and the next will occur in 1832. A transit of Venus happened in 1639, but the next will not occur till 1874, which some of us I hope will live to see.

How beautiful such a phenomenon must be! exclaimed Eugenia. A jetty spot in the midst of overpowering brightness!

But, continued Franklyn, I have mentioned all this by the way—and indeed somewhat out of the way—in order to illustrate our previous subject. For you have only to substitute the Moon, in a transit of Venus, for that planet, and to suppose the disc of the Sun thereby *totally* covered; instead of a small black spot, a large one the size of the Sun would thus, as I have said, be produced, though no more defect of Sunlight would, on that account, ensue from the Moon than from the planet, unless—mark this!—unless within the cone which has been described to stand upon her like an *extinguisher*.

But how is it, then, demanded the Colonel, that if this cone be indeed an "extinguisher," we yet see the Moon in an eclipse?

Understand a little more of the theory, and you will be able to answer your own question. An *eclipse* would take place when, the Moon being between the Sun and the Earth, that cone, or pointed cap of darkness, which we have been speaking of, happened to *reach the Earth.*

Ah! now I perceive! exclaimed Reginald: we should then be *inside* of the extinguisher, from which, as you explained, the Sunlight is excluded?

Yes, said Franklyn; but recollect that, as the Moon is so small with regard to the Earth, and is likewise always so distant from us, but a very small part of the Earth's surface is inside the extinguisher at a time. To all the inhabitants of *that part* there will be an eclipse of the Sun, but not to *any other* part of the Earth's surface; which explains how an eclipse of the Sun may be visible at one place and invisible at another. For example, if the Moon's conical shadow pointed towards Earth, and the London side of Earth happening to be presented to the Moon, if the steeple of St. Paul's Church pointed towards the Moon; then it is evident, that the *tip* of the conical shadow might just reach the lantern on the top of St. Paul's steeple, so as barely to envelop it, and a solitary person in the lantern would, therefore, be enveloped in the shadow, that is, the Sun would be eclipsed to him, and to him only.

Such a curious situation!

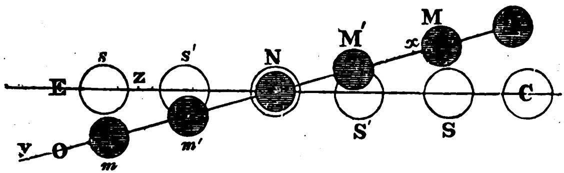
But if the Moon were so near that the tip of her shadow reached the *floor* of St. Paul's, then the lantern would be a good way up in the shadow; and as the shadow broadens towards the Moon, perhaps the whole dome, or more, of the Church would now be in darkness; and therefore an eclipse would take place with all persons in that dome, although no eclipse would take place with persons outside the church. Again, if the Moon were still nearer, so near that the tip of her shadow might be supposed to reach below the *vaults* of the church, and the breadth of the shadow on the ground equal to the breadth of St. Paul's *churchyard;* then, an eclipse would be visible to all persons (I mean *living* ones) in that churchyard, but invisible to all outside. Let the Moon be yet nearer,—and all London may perceive an eclipse, if the breadth of the shadow be equal to the diameter of that enormous metropolis. But no one outside this shadow, where it meets, or lies upon the earth, will perceive the darkness.

Then, in like manner, said the Colonel, all Middlesex, all England, might perceive an eclipse, while the rest of the earth knew nothing about it.

Not exactly. All England could not perceive an eclipse at the same time; for the Moon never comes so near the earth that the breadth of her shadow on its surface exceeds about 180 miles. Now England is broader than this both ways; being 400 from the Tweed to the British Channel, and 300 from the Irish Channel to the German Ocean. So that all England could not be covered at once by the shadow; but nearly all *Ireland* might. Besides, I have to inform you that there is a kind of *secondary* shadow, accompanying the primary one, but of quite a different shape, which is called the *penumbra*; and this may extend over a great portion of the terrestrial hemisphere presented to the Sun, so as to cause a partial darkness, or semi-eclipse; for the penumbra is only a kind of faint shadow.

Penumbra! said Eugenia, what is the meaning of this odd term?

Put your arm within mine, answered Franklyn, and I will explain this odd term, as we walk homeward. Penumbra is a Latin complex word, made up of two simple ones, videlicet: *pene*, which signifies *almost*, and *umbra* a shade. Penumbra, therefore, means a *half-shade*, or faint shade, which I describe the thing itself to be. I will tell you some other time how it is produced.



EVENING EIGHTH.

We were talking last night of Eclipses, said Franklyn.

Yes, said Isabel, interrupting him; I have a perfect notion of what they are from the description you gave us: let us now speak of something else.

Just *one* question before we quit this subject, rejoined Franklyn. How many eclipses of the Sun take place in a year? I address myself, continued he finding that no one made reply, to you, Miss Isabel. Your "perfect notion" of eclipses will of course enable you to answer the question without difficulty.

Why, returned she, quite at her wit's end, if, as you supposed last night, the Moon's apparent path lay exactly within the Sun's all round the sky, and if she always kept between him and us, and if her shadow was always long enough to reach the Earth,——

Hoity-toity! how many *ifs* are here? I know very well that *if* all these things took place, there would be always an eclipse at some part or other of the Earth, namely, wherever the shadow reached; a sort of *travelling* eclipse, which would pass from place to place all round the Earth as she turned on her axis, and successively presented her different sides to the shadow; a kind of *eclipse going-circuit*. As Robin Goodfellow says, the Moon would thus put a cloudy "girdle round the Earth" day after day, and the Sun would appear to be blotted out, when he was passing over the meridian of each place, that is, just when he ought to be seen in his full noontide splendor. But not one of these suppositions is true. The Moon's path does *not* lie exactly within the Sun's, but *crosses* it at two opposite points of the sky, which points I have already told you are called *nodes*. Again, the Moon is *not* "always" between the Sun and us, but very seldom so. For, supposing her, at any time, between the Sun and us, she, moving so much faster than he, will soon get out of that line; and before she has any chance of getting into it again, must travel round the whole sky from whence she first set out; nay *farther*, inasmuch as he has proceeded, however sluggishly, on *his* way, so that she has to travel *this also*, ere she can overtake him. Finally, the Moon's shadow is *not* always long enough to reach the Earth; for its length varies from $55\frac{1}{2}$ to $60\frac{1}{2}$ semi-diameters of the Earth (according as the distance between her and the Sun is less or more), while she is herself sometimes even 65 semi-diameters of the Earth distant from us.

Then it is plain, subjoined the Colonel, that if she be at her greatest distance from the Earth, her shadow cannot possibly reach us, even were it likewise at its greatest length, inasmuch as 65 semi-diameters is more than $60\frac{1}{2}$.

But, continued Franklyn, her distance from the Earth is sometimes only 56 of those semi-diameters, and then, indeed, if the length of her shadow be not at its very least, namely, $55\frac{1}{2}$ semi-diameters, it may reach some place on the Earth, and so cause an eclipse.

It *may*?—no, but it *must*! said Reginald.

Not unless at that very epoch she happen to be in a line between the Sun and Earth. For, as one half of her orbit or apparent path is above that of the Sun, and the other half below it, a straight line from the Sun behind her to Earth might not pass through her, if she were in either the upper or lower part of her orbit. Hence, her shadow would not be projected along that line toward us, but *up* into the sky, or *down* it.

Yes, like the tail of a Comet, said the Colonel illustrating his nephew's position.

Somewhat,—but that the one is visible, the other not.

And why is not the Moon's tail visible like that of the Comet?

Because the latter is a luminous *substance*, though of what kind astronomers are not agreed, *only* that it is thin, and vapory. But the former is a mere *shape*, from within which light is excluded, so that having no substance it cannot be seen.

Why? May not darkness be visible? demanded the Colonel. Do I not see that black shadow of a tree on the wall of my house?

You see the *wall*, because it is a substance; and you see the *outline* of the shadow on it, because that outline, being part of the wall, is likewise substance. From seeing the material outline of the shadow, you see the *shape* of the shadow, and you see that within the said outline there is no light; this is generally called, seeing the shadow itself. Now, continued our Metaphysician, if there were a *wall*, or substance of any kind, on which the Moon's shadow was thrown, we should see, in like manner, the outline of the shadow upon this, and see that within the outline there was darkness,—or, in common phrase, we should see the shadow itself. Such wall, or substance, not existing in the pure æther through which the shadow moves, we cannot see the shadow.

Nevertheless, said Eugenia, what a sublime idea it affords us! An immense cone of darkness, based upon the Moon, stretching so far into the celestial void around her, and moving eternally through the vast expanse of Heaven, according as the Sun and Moon change their positions!

Yes,—as it were in search of something to feed upon; alternately contracting and pushing itself out, like a gigantic *feeler:* but, fot all it sgrandeur, invisible to those outside, and for all its terrific movements perfectly harmless! By the by, added our imaginative Astronomer changing his tone of sublimity, you must know that, if you were seated inside of the cone itself, you would not find it so dark as you suppose.

What then? how can it be otherwise?

You remember the great eclipse of 1820; this was nearly a *total* eclipse, because nearly the *whole* Sun was concealed. Well, was it very dark then? demanded Franklyn.

No, certainly; not even so dark as many a cloudy day is.

In the year 1715, however, said Franklyn, when a total eclipse of the Sun took place, at about nine in the morning, the planets Jupiter, Venus, and Mercury, as well as certain of the brighter fixed stars, became visible, and the darkness lasted nearly three minutes and a half. But even then it was not pitch-dark, as we say; and from this cause: the rays of the sun, which fall outside the shadow, are reflected from different parts of the atmosphere, in all directions; many of these reflected rays, therefore, enter the shadow, and scatter a faint, hazy light through it. There is another cause, which, however, produces but little effect in eclipses of the Sun; I shall explain it when we come to eclipses of the Moon.

You have not yet answered the first question which you proposed to Isabel, said Mrs. St. George, and which puzzled us all.

"How many eclipses of the Sun happen in a year?" *Two* there must, and *five* there may be. From what has been already explained, you see that eclipses can only take place when the Moon is in, or near, one of her *nodes;* because when in the upper or lower part of her orbit she cannot come between the Sun and Earth, and therefore her conical shadow does not lie in the plane of the Earth's orbit, so as to reach us, however long it may be. Now, if when the Moon is *in* one of her nodes, the Sun should be in that part of his orbit exactly behind this node, that is to say, should be on a line with the Earth and Moon, only a great way farther from the Earth than the Moon is,—her shadow would then be pointed exactly towards the Earth's centre, and if it were long enough to reach us, the eclipse would be denominated a *central* one. If the shadow were *not* long enough to reach us, the Moon, as I described last night, would nevertheless appear like a brown blot, exactly in the middle of the Sun's disc, and would nearly cover it wholly, as her apparent disc is nearly as large as his. Merely the outward *rim*, or *ring*, of the Sun's disc would be visible; and hence this phenomenon is called an *annular* eclipse (from *annulus*, the Latin for ring). And an eclipse, which is neither central nor annular, may take place, when the Earth, Moon, or Sun, are not *exactly* on a line, but nearly so; that is, when the Moon is not *in* one of her nodes, but *near* it, and the Sun in a due position behind her. For though her shadow will not be pointed *exactly* towards the Earth's *centre*, it will be pointed a little slantingly towards the Earth; and as the Earth is so large a body, her shadow may pass over one part or other of it; in other words, there may be an eclipse. Nay, there *must* be one in or about each node; for here, where the apparent paths of Sun and Moon cross each other, they are so close, that if these bodies be both near the crossing at the same time, each in its own orbit, *part* of the Moon, at least, will glide over part of the Sun, and so cause an eclipse.

Nay, Mr. Astronomer! cried Eugenia; not unless her shadow be, at the same time, *long enough to reach the earth.*

"A hit! a very palpable hit!" I am taken like "a woodcock, in mine own springe!" theatrically exclaimed he. Why, true! if we define an eclipse to be a darkness caused by the shadow of one body projected on another, then, indeed, there may not be *any* eclipse in the year; and the phenomenon which I have just described would be only a *transit*, or *occultation*, or obscuration of part of the Sun's disc by part of the Moon's. But, in common parlance, these obscurations are called eclipses; and the greater number of those so called in Almanacks are eclipses of this kind, mere *shadowless* eclipses, mere *interpositions* of some part of the Moon's body between us and the Sun, so as to conceal a part of his circular disc.

Ay, but, interposed Isabel, I have to take you to task on my own account. You said that there *must* be an eclipse in or about each node, for that *if* the Sun and Moon were both near it at the same time——Now, what have I to do with your *ifs?*

Franklyn,—at this recriminative sally, the more piquant on account of an extreme *naïvete*, and characteristic quickness of manner which distinguished all that the speaker said,—could not help uttering a shout, almost loud enough to be heard at the Moon.

I have taught mine enemies to wound me with mine own weapons! said he. But (resuming his gravity) it fortunately happens that I can substantiate my ifs, whilst yours were *wholly* gratuitous. You must understand, then, that measuring about fifteen degrees, or a twenty-fourth part of the whole ecliptic, on each side of the node; the two spaces thus measured, making together one arch of about 30 degrees,—Phœbus's golden chariot would be about 30 days rolling from one end to the other of this arch.

Why?

Because the Sun completes the whole ecliptic circle, of 360 degrees, in about 365 days, and therefore must perform a journey of about one degree, or something less, in a day. Look here, now: [he drew a figure. See the engraving at the head of this EVENING.] Suppose E C to represent an arch of the ecliptic, O T an arch of the Moon's orbit, crossing the ecliptic at the point under N; this point will be a *node*. Suppose the arch from N to S be 15 degrees long, as likewise the arch from N to *s*; the whole length of *s* S is, therefore, about 30 degrees; and the Sun setting out from S would be nearly 30 days, or a month, in travelling to *s*. But, at any point between S and *s*, an eclipse, or obscuration of the Sun, would happen, were he and the Moon to come together as at S and M, S′ and M′, N, *s*′ and *m*′, *s* and *m*,—though at S and M, *s* and *m*, since the rims only would meet, it could hardly be called an eclipse, or obscuration, with strict propriety.

I suppose, because the two paths are so close to each other from S to *s*, remarked Eugenia.

Just so: at S or *s*, the discs of the Sun and Moon would just touch; that is, their two semi-diameters would exactly measure the distance between their centres. Nearer to N, the node, the distance would be less, and therefore the dark disc of the Moon, M′, would obscure part of the bright disc of the Sun S′. But farther from this node, as at C and

T, this distance of the centres would be greater than the two semi-diameters together, and therefore the bodies would not touch. Similar circumstances will take place at the other side of the node, where the Sun and Moon are represented by s' and m', s and m. Hence, the arches N S and Ns are called the *ecliptic limits*,—because an eclipse cannot take place beyond those limits. When the Sun and Moon come together in the node itself, if the Moon's apparent disc is *smaller* than that of the Sun, there will be an *annular* eclipse, as I have attempted to represent in this figure, by leaving a bright ring around the dark body of the Moon; if the Moon's apparent disc be as large as that of the Sun, there will be a *total and central* eclipse, as her dark body will then appear to fill up the whole bright circle of the Sun, and blot him out from our view.

This is all very fine! said the pertinacious Girl; but still I have not been answered. How do I know that while the Sun passes from S to s, the Moon will come between us and him? So regularly too!—twice a year!

Consider for a moment. Let us take the most unfavourable case, and suppose that when the Sun is at S, the Moon is a little before him, as at x, so that he should have the best chance of getting to s, before she can overtake him,—she having to move through her whole orbit, as far as x again, and a considerable nodal arch from *x* in addition. Let her set out, then, with all this advantage: when will she arrive at *x* again?

In twenty-seven days, I think you told us, said Eugenia.

About that. Where will the Sun be at this time?

Why, as he travels nearly a degree a day, and as from S to *s* is 30 degrees, he will be nearly within three degrees of *s*, replied the Colonel.

Very good; say that he will be at z. He will then have somewhat more than three days' journey to reach *s*: now tell me how far the Moon will have advanced from *x* in three days?

40 degrees, said the Colonel, after some calculation.

More accurately, 39; for as she travels 360 degrees in 27 days, dividing 360 by 27, gives about 13 degrees for her advance in one day. Hence we see that before the Sun can have moved from *z* to *s*, the Moon will have moved through a greater arch than S *s*, say to about *y*; and hence, Miss Isabel, you see that she must have passed him within the ecliptic limit N *s*, and therefore occasioned an eclipse or obscuration. I grant that our computations have not been mathematically exact; nor have a number of qualifying little circumstances (such as the *retrogradation of the node*, the change in the apparent lunar and solar diameters on account of the change in the distances of these bodies from the

Earth,) been stated; but if all the necessary corrections were introduced, our process would be only the more definite, and the result only a little more scientifically demonstrative.

You have proved that *one* eclipse will happen, said Isabel, but where are all the others?

Remember that I spoke positively but of *two*, replied Franklyn. The second will happen at the *other node*, in the same manner as the first did at this.

Well, and how do you shew that *five* eclipses of the Sun *may* happen in a year?

I have stated the ecliptic limits at their *very least*; for in them it is supposed that the Moon's apparent diameter at M and *m* is the least possible. But should the Moon's apparent diameter be the greatest possible, it is evident that her disc would meet the Sun's when she and the Sun were farther asunder than M and S, *i. e.* at a greater distance from the node than S and *s*. Hence, although 30 degrees is the length of the nodal arch S *s*, within which an eclipse *must* happen, the length of that within which an eclipse *may* happen is about 34 degrees. Now, if one eclipse happen at the beginning of this arch, another may happen (in the way I have already shewn) before the Sun gets to the end of it. There will be *two* eclipses, and two for each node makes *four* in all. As to the *fifth*—

Yes, the fifth! Come, we have puzzled him at last, exclaimed Isabel.

You grant, replied he after a pretty long fit of cogitation, that the first of these four eclipses—when the Sun is at C, for example—*may* happen at the very commencement of the year?

Yes.

And you recollect that the nodes will have *retrograded* about 20 degrees at the end of the year?

I do.

Well then; just before the end of the year, *i. e.* just before the Sun has come round to C again, the node will have retrograded from N beyond S, to about C, and the ecliptic limit will be still farther from N than C is, *viz.*: 17 degrees farther. Consequently, in approaching C to complete his annual course, the Sun will have to pass through that very ecliptic limit of 17 degrees, which lies nearer to him than C; and thus may the fifth eclipse happen.

You provoking fellow! I will listen to no more Astronomy this evening! said she, and walked away in great dudgeon.

> "Stay, my Statira! stay, my angry dear!"

exclaimed Franklyn, with affected contrition. Behold these penitential drops I shed to allay the flame of thy indignation!

> "So weeps the wounded balsam; so
> The holy frankincense doth flow;
> The brotherless Heliades
> Melt in such amber tears as these!"

Turn, Isabella, ever dear! and I will tell you a pretty story about these "brotherless Heliades." They were certain Nymphs, who on the fall of their brother Phaeton from his father Apollo's chariot, which you know he rashly attempted to guide,—wept so piteously, that the gods changed them into poplars, and their tears into amber. They may truly be said to have become wood-nymphs, and it is to their contributions that Pope alludes, where he says, that

> "Trees weep amber on the banks of Po;"

inasmuch as it was on the banks of this celebrated river they were supposed to stand, "augmenting it with tears."

This is a pretty fiction, said Eugenia. But why are they called Heliades?

The Greek *Helios* means the Sun, and as they were daughters of Phœbus, Heliades became their patronymic title, like Atrides for Agamemnon, the son of Atreus, and general of the Greeks at the siege of Troy; Pelides for Achilles, the son of Peleus; and Tydides for Diomed, the son of Tydeus, both celebrated heroes at the same siege. Patronymic means *paternal name*, from the Greek *pater* father, and *onoma* name. It is observable, however, that this way of supplying one person with the modified appellation of another was not confined to *paternal* names; as, for example, these very

Heliades were also called *Phaetontiades*, from their brother Phaeton.

Was there any real foundation, I wonder, for this extraordinary fable? inquired Eugenia.

Probably, a phenomenon of the very kind we have been discussing,—an eclipse of the Sun, replied her Father.

That, perhaps, is not so likely, observed Franklyn, as the phenomenon, whatever it was, indicates rather a superabundance of Sunlight, than a defect. It was a conflagration, by which the Earth appears to have endured some inconvenience.

May be the Sun happened to come nearer the Earth on that occasion? said Reginald.

You mean the Earth went nearer the Sun, replied Franklyn. I do not know how that may have been; we have neither record nor tradition of such an event. This, indeed, we learn from the doctrine of gravity (Newton's great discovery, which I believe I have already mentioned), that whatever *natural* disturbances take place in our system, changing the orbits of the several bodies, they are all inconsiderable, and counteract each other, either immediately or ultimately; so that it is not very probable the Earth ever deviated much from its usual course. Thus, for example, we know that the Moon now moves faster in her orbit than she did two thousand years ago, and that her motion is in a state of continued *acceleration*. From this circumstance, it has been concluded by some philosophers, that her orbit is becoming gradually smaller and smaller, that she is imperceptibly approaching us every year, and that at length she will roll like a huge ball around the Earth's surface. But this supposed final event will never take place; at least from any physical cause now existing. For it has been mathematically demonstrated, on the principles of gravity, that this acceleration of the Moon's motion can never exceed a certain quantity (by reason of counteracting disturbances in our system); that a *retardation* will set in after a very long period of time has elapsed; and that the Moon's rate of motion being diminished by the same degrees as it was increased, will at length return to that from which it begun, and will then commence a new period of alternate acceleration and retardation. This kind of irregularity in the Moon's motion is called *periodical*, inasmuch as it is completed, corrected, and renewed, in a certain period. And, indeed, there are similar periodical irregularities in the motions of almost every body in the universe.

How can this astronomical *prophecy*, as it may be called, that a retardation of the Moon will set in after a very long period,—how can this have been mathematically demonstrated? asked Eugenia.

I cannot at this moment charge my memory with the process, replied Franklyn; but if your anxiety be very great, you have only to consult *Laplace*'s celebrated work, the *Mécanique Celeste*, where you will find the entire detail set forth in its most pleasing form, and embellished with all the graces which the Trigonometrical and Fluxional Calculus can bestow on so interesting a subject.

Ah, ridiculous! Well, can you explain, without referring us to Laplace and his *trigonometrical* treatise, how it is *known* that the Moon really does move faster now than she did two thousand years ago?

It is known by the doctrine of *Eclipses*. Nay, I am serious: you will never find me cajoling you with false knowledge, which I hold too sacred for such profanation, though I may occasionally give way to a harmless jest, when perhaps I can furnish nothing better. Three eclipses of the *Moon* which were observed at Babylon, in the years 719 and 720 before the Christian era, are the earliest recorded with astronomical precision; for you know the Chaldeans of old were profound astronomers for that time, as we read in Scripture. We have also ancient observations of eclipses made by the philosophers of Egypt; and others by the Arabians (who were still better astronomers than the Babylonians), in what are called the "Dark" or "Middle Ages;" that is, about the eighth or ninth centuries of the modern world. Now, proceeded Franklyn, these observations can neither be reconciled with each other, nor with those eclipses which happen at present, unless we suppose the Moon's rate of motion to have been constantly accelerated.

I do not understand this, said Isabel.

We must premise, I see, a little, concerning eclipses of the *Moon*, returned Franklyn.

As solar eclipses are occasioned by the *Moon* coming between the *Sun* and *Earth*, so lunar eclipses are occasioned by the *Earth* coming between the *Sun* and *Moon*. When the Sun is exactly behind one of the Moon's nodes, a conical shadow of the earth is projected exactly towards the other, which is exactly at the opposite point of the heavens. Hence, should the Moon happen to be in the latter node at this epoch, she would suffer an eclipse.

If the Earth's shadow were long enough to reach her, subjoined Isabel correctingly.

Oh! that is always the case, replied Franklyn: for the distance of the Moon from the Earth is only about 65 terrestrial semi-diameters at most, while the length of the Earth's shadow is never less than about 213 of the same semi-diameters. So that, in fact, the Moon would pass through the shadow at not a third of its whole length, and would therefore be for a considerable time in darkness. Such an eclipse as I have described is said to be *total* and *central*, because the *whole* Moon is immersed in the shadow, and because its centre passes through the centre of the shadow's breadth at that place. But so great is the breadth of the Earth's shadow at a third of its whole length, that the Moon may be wholly immersed in it without passing through its centre; and then the eclipse will be *total*, though *not* central. When the eclipse is both total and central (or it might be called *central* alone, as if it be central it *must* also be total), it may last for nearly *two hours;* because the breadth of the shadow through which she passes is sometimes thrice *her* breadth, and you know that she moves through an arch of her orbit equal to her own diameter in about an hour.

If the breadth of the shadow be thrice her diameter, and if she pass over a space equal to once her diameter in an hour, said Eugenia, why may she not be eclipsed for *three* hours?

She certainly may, replied Franklyn, if we reckon from the time that she first touched the shadow until she last touched it, from the commencement of her *ingress* to the conclusion of her *egress;* but you must recollect that, before the eclipse can be called *total*, she must be wholly immersed: that is, she must have gone *one* diameter into the shadow, and therefore has only *two* more to pass over, ere she begins to emerge again.

In an eclipse of the Moon, then, said Isabel interrogatively, she and the Sun are exactly in the opposite nodes?

Not always in *exactly* the opposite nodes, returned Franklyn; for though the Sun be at one side of one node, not very far from it, an eclipse may take place, if the Moon be opposite him at the contrary side of the other node. But, in this case, the eclipse cannot be accurately *central*, as, on account of her orbit being inclined to the ecliptic, she will be either above or below the centre of the shadow.

There are, in fact, observed the Colonel, *ecliptic limits* for the Moon as well as for the Sun?

There are. If the Moon be within $11\frac{1}{2}$ degrees of her node, at either side, an eclipse may happen; but if she be at a greater distance from her node, an eclipse cannot happen. Eleven degrees and a half is therefore the length of each ecliptic limit, and 23 degrees the length of both, or of that whole arch within which an eclipse may happen. Beyond the extremities of this arch, she will be either so much above or below the ecliptic circle, that her disc will not touch the shadow which points, something like a great conical index, to its circumference.

I think you said that *two* eclipses of the Moon take place every year? observed Mrs. St. George.

Not that they *do*, but that they *may*. One may take place at each node, if the Sun happen to be opposite the Moon while she is within her ecliptic limits. But as he is only about 23 days in passing over the 23 limitary degrees at each node, it is very possible for him to finish both these brief journeys without finding himself opposite to her. For example, if he be about entering upon the ecliptic limits at one node, while she is about quitting them at the other, he will have passed over the former limits in twenty-three days, long before she can have returned within the latter limits, so as to come opposite him. Tell me *how* long?

Eugenia! why don't you answer that simple question? exclaimed her Sister pretending not to know that it was herself who had been interrogated.

I cannot think of stepping between you and your glory, replied Eugenia: pray take the opportunity for triumph which this problem affords you.

Come! I see there is no likelihood of getting an answer from either of you, so I will e'en give it myself, said Franklyn. In twenty-three days the Moon will have travelled about 306 degrees, which is 54 from completing a whole revolution to where she quitted the ecliptic limits, and consequently 31 degrees from entering upon those limits. Hence, as she goes $13\frac{1}{3}$ degrees in a day, she will have about *two days'* journey ere she can reach the ecliptic limits; and therefore no eclipse will take place on this occasion. Similar circumstances may happen at the other node, and for this reason there may be *no* eclipse of the Moon in the year.

On consulting the Almanac for this year last night, said the Colonel—for, having gained some little knowledge on the subject of eclipses, I have become doubly interested about such occurrences—I there found that there are to be *two* eclipses of the Sun, but both of them invisible to us; and also *two* eclipses of the Moon, one only of which will be visible at Greenwich.

Yes; I forget how long it will continue, said Franklyn.

It will begin, replied the Colonel, twenty-five minutes before five in the morning, and end forty-nine minutes before seven.

More than two hours, you perceive, observed Franklyn; but the Moon will not be totally immersed; the eclipse will be but *partial.*

What does the Almanac mean by saying, "*Digits* eclipsed, $6^{0}\ 5'$ on the Moon's southern *limb*?"

If you conceive the diameter of the Moon's disc to be divided into twelve equal parts, these parts are called *digits*, from being usually marked by the numeral digits 1, 2, 3, &c. We then say that there are so many digits eclipsed, according to the number of such parts obscured by the shadow. Digits, however, are sometimes called *degrees;* and, like the degrees of a circle, are each of them divided into 60 equal parts, called *minutes:* they are likewise written like ordinary degrees and minutes, as you found them in the Almanac. Thus, "digits eclipsed $6^{0}\ 5'$," means, that there will be 6 digits, and five sixtieth-parts of a digit, obscured by the shadow which will pass over the disc of the Moon, September 13th of this year (1829). As to the Moon's "southern *limb*," this only means that the southern part *of her body* will be that which is eclipsed. I grant the phrase to be somewhat singular, and very seldom appropriate.

Can you now explain about the *acceleration* of the Moon? said Eugenia.

I will try. But of all things I despise *parrot-*knowledge (which is too much in vogue now-a-days); and I dislike still more to impart it. What you do learn from me, I should wish you to learn understandingly, and not in any measure by rote; so that your minds may be filled, but not inflated. Believe me, you will have far more satisfaction in a little sound knowledge, than in a great quantity of superficial. Recollect the distinction between *Information* and *Knowledge:* the first is only a mass of *facts* unexamined; the second, a system of *truths* understood. Now, any one who possesses *memory* may possess information, but none can possess knowledge who does not possess *mind.* To be sure, memory is a "limb" of the mind, except where this term is used, as I now use it, to express by way of eminence the reasoning part of the soul. I very much fear that, with your slender knowledge of astronomy, any thing you can learn with respect to the Moon's *accelerated* velocity must come under the head of mere *Information;* but such a pretty, scientifical word as "acceleration," especially when conjoined with "velocity," acceleration of *lunar* velocity! will be a splendid ornament to your discourse at the next quadrille party.

Then I don't want to hear it! said Eugenia somewhat nettled at the imputation.

Isabel, who was not quite so sensitive, desired *Doctor Johnson, junior* (as she ludicrously nicknamed her most uncomplimentary Cousin), to "vanish from her offended presence, with *accelerated velocity!*"

This restored complete harmony, and Doctor Johnson, junior, continued.

If the Moon's nodes were *fixed*, eclipses would always take place at the same time of the year; inasmuch as they depend on the Sun's position in the zodiac, or ecliptic. For instance, if one node were fixed at the 15th or middle degree of *Aries*, and the other consequently at the 15th or middle degree of *Libra*, eclipses would always happen when the Sun was in these Signs, *i. e.* at the same time of the year*. But as the nodes *retrograde*, that is, move round in an opposite direction to the course of the Sun, so as apparently to meet him before he has finished the whole circumference of the heavens; on this account eclipses will happen *sooner* every year. *Par exemple:* if an eclipse

* It cannot be properly said at the same *season* of the year, because the seasons change, however slowly, unless rendered permanent by an artifice which will be explained hereafter. Thus, in 1577, the day of the spring equinox fell on the 11th instead of the 21st of March, thereby bringing on the summer season ten days too soon in the year, considered as beginning on the 1st of January.

happened this year when the sun and node were at the 30th or last degree of Aries, the node, moving back with respect to the signs about 20 degrees in a year, would be about the 10th degree of Aries when the Sun came round to meet it in the same sign next year; that is, the Sun and node would apparently meet at a point of the ecliptic nearly 20 days' (or more accurately 19 days') journey short of his complete revolution; or, in other words, 19 days earlier in the year. So that, if an eclipse now took place, it would be so much earlier. Do you understand this?

Pretty well: but I wish those provoking nodes would stay in one place, and then all would be so simple! exclaimed one of the party who needs not be specified.

Well! continued Franklyn, you see now that it is very possible to calculate the time of eclipses, either forward or backward; either those which are to happen, or those which have happened, as we know that they happen a certain number of days earlier each year.

Oh yes! very easy indeed! said Isabel.

Not quite so easy as you seem to think; for you will recollect, that various allowances are to be made as well as that concerning the node. If a central eclipse take place this year, it does not follow that a central eclipse will take place nineteen days sooner next year, although the sun may be in the very same node; because the *Moon* may not be then exactly opposite to him, as she was before. As we know, however, the rate at which the Moon moves through the heavens, and also the rate at which the nodes move in a contrary direction, we can with some trouble compute where both will be, or may have been, at any given period, forward or backward, from the time when an eclipse took place, when they were in certain positions with respect to each other, the Sun, and the fixed stars. By a computation of this sort, Thales, the ancient philosopher, and Wise Man of Ephesus, foretold an eclipse, which he turned to a most excellent account,—that of bringing about peace between the Medes and Lydians, on whose superstitious ignorance he palmed the phenomenon, as a symbol of divine displeasure at their proposed contest.

I think, in the Life of Columbus, we read of that great and pious man having practised a similar artifice, said the Colonel; in order to obtain provisions for his famished crew, which the inhuman islanders of Jamaica refused him.

Yes; he threatened them with a pestilence, and, as a symptom of its approach, told them there would be an eclipse on a certain day. Accordingly, this phenomenon took place, as he had prognosticated, which so terrified the simple inhabitants, that they became in an instant perfectly philanthropical, supplying him with every thing he wanted, if he would only have the kindness to uncover the Sun, and so relieve them from the pestilence. Christopher was not inexorable; he yielded, good soul! to their prayers and contrite lamentations: the darkness passed away in a short time, and he set sail with a shipload of "*provant*," thanking his stars, I suppose, that he knew enough of Astronomy to frighten those who knew nothing of it into the semblance of a virtue so beneficial in its effects to him and his companions. But this is a sad digression! However, I have only to say, that computing the times when those eclipses which I mentioned, observed by the Chaldeans and Arabians, *ought* to have taken place, we find that these times will not agree with the times recorded, unless we suppose the Moon's velocity to have been less then than it is now; less also at the time of the Chaldean than the Arabian observation; and, in fact, proportionably less as we penetrate into what Shakspeare finely calls

> "The dark backward and abysm of time."

But our discourse has already lasted too long, and therefore I will close the portcullis of my mouth for the present; although at such an hour as this I always feel myself vastly disposed to quotation.

We will allow you *ten* lines, said Eugenia, from whatever melodious poet you please, in order to "draw us home with music."

I will take but *eight* from an old English Bard; as it seems to me most beautifully descriptive of "Night's Companion,"—Sleep, and the kind officiousness with which she tends us mortals from couch to couch:

> "Now hath the Night's Companion from her den,
> Where all the busy day she close doth lie,
> With her soft wing wiped from the brows of men
> Day's sweat; and by a gentle tyranny
> And sweet oppression, kindly cheating them
> Of all their cares, tamed the rebellious eye
> Of sorrow; with a soft and downy hand
> Sealing all lids beneath the Moon's command!"

O, beautiful! exclaimed Eugenia in perfect rapture; how sweet! how inexpressibly tender! what exquisitely delicate language! her "*gentle tyranny* and *sweet oppression* cheating us of our cares," and "taming the *rebellious eye of sorrow.*"

The last, especially, observed the Quoter, is a highly poetical thought, and most happily expressed. That is also a beautiful image, "with her soft wing wiped from the brows of men Day's sweat;" and not the less beautiful from its Scriptural nature,—alluding to the curse pronounced in Genesis on Man the sinner.

Yes, and the last—— said Isabel.

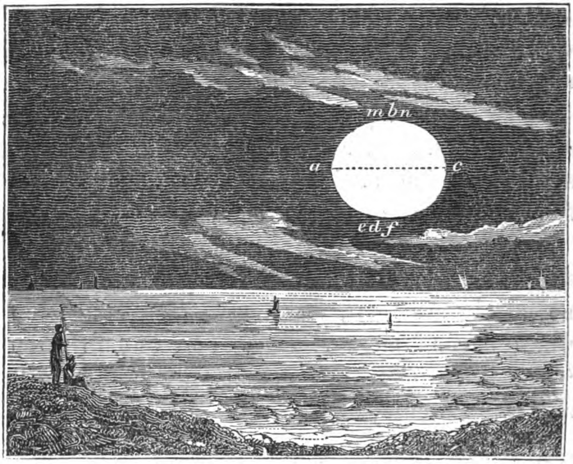
Stop! I fervently recommend you. Take care what you say of the last line, for it is not by the old author; so you might commit yourself! The original line, for which some audacious modern has substituted one of his own, is

> "Sealing all breasts with a Lethean band;"

the meaning of which is not very evident, unless we are acquainted with the antique method of sealing letters; which was by means of a thread or silken string forming a "band," to secure what is now more conveniently fastened by wax or wafer.

Come! there was *some* use in the quotation after all, said Mrs. St. George; it has led to a piece of antiquarian information, which I did not expect from Franklyn in his present humour.

Alas! replied he, with an equivocal smile of contempt; but there is a great deal of poetry which has no earthly use in it, affording us nothing in the world beyond mere *pleasure!* and who in these "practical" times, does not heartily despise such an irrational enjoyment?



EVENING NINTH.

A LITTLE after dusk the next evening, as one of the parlour casements gradually and as if voluntarily opened, a beautiful strain of melody was heard without, distant but ineffably clear.

The nightingale! ejaculated Franklyn, and immediately jumped through the window, followed by Reginald.

That was not the mode of exit suited either to the Colonel or the Ladies; who, however, took the usual route out of doors, attracted, though less violently, by the same sounds which had excited the activity of their Cousin and his *satellite*. Both divisions of the party alternately calling and answering, while each recommended its own position to the other, as that best selected for enjoying the delightful music, effectually prevented either from hearing it; and when they had at length joined forces at "the best listening place in the whole orchard," behold! the terrified musician was gone! Franklyn, with ears almost as long as Midas's, stood in deep expectation for several minutes, frowning and making hideous grimaces, when Isabel, who was no *Griselda*, once or twice impatiently attempted to break silence. At last, shrugging up his shoulders, with a sigh of disappointment, he exclaimed,—The perverse little wretch! They say it is only male birds which sing, and truly I would believe the allegation, were it only from the fact of this one being so easily put to silence!

Whenever our Hero was chagrined, it was always observable that he vented his ill humour in some gibe or sarcasm upon the unoffending sex, whom we believe in our hearts he secretly idolized. Being familiar with his disposition, no one present thought of resenting his assumed ungallantry: it only created a smile.

How does it happen, asked Eugenia, that so untender a being as you should love with such fervour the pathetic music of the nightingale?

The question was replied to in a manner which no one (except the Respondent himself) could immediately understand, but which became intelligible in the sequel. Looking wistfully towards the grove whence he had heard the lovely music, our Unaccountable, as if addressing the object of his admiration, began—

> "O come, my mate, break off thy slumbers,
> And round thee fling thy plaintive numbers
> In a most melodious hymn,
> Warbled from thy brown throat dim.
> For Itys our beloved son,
> Thine and mine, now dead and gone!
> Fill the forest with thy moaning;
> Till through the woodbine boughs the groaning
> Of thy voice to Jove's seat climb,
> And mingle with the starry chime,
> Where golden-tressed Phœbus soon
> Shall answer in as sad a tune,
> From his ivory-clasped lyre
> That leads in dance the stately quire;
> And from the blest above shall flow,
> A peal accordant to thy woe!"

Dear Franklyn! cried Eugenia, whose is that beautiful song? Is it Milton's?

Not exactly Milton's, but certainly *Miltonian*, answered he. It is by one of the very best of men, and of translators,—one for whose genius and delightful simplicity of character I have a particular respect, though I sometimes irreverently jest with him,—the translator of Dante.

I have often—often wished to read that work! said Eugenia.

Such an acknowledgment is by no means to your credit, I beg leave to tell you, returned he with a degree of real austerity.

Wherefore, dear Franklyn? I thought you considered it one of the finest poems in the English language!

Because you should have read it *long ago!* Every one who *pretends* to a love of genuine poetry should have read it; but as to poetry, we are now a mere nation of janglers and lovers of jangle!

[This was a subject on which our friend was apt to become, as he owned himself, a little mad-headed; so Eugenia thought well to change it.]

In what part of Dante does that Invocation to the Nightingale occur? she said somewhat timidly.

If it occurred in Dante at all, replied the Ascetic, it should occur in the *Paradiso.* But it is from the works of a much more unlikely author: it is from a drama by the greatest droll of antiquity,—Aristophanes.

Aristophanes! Why from his reputation as a satirist and comic writer, a buffoon and eternal scorner, I should as soon have expected this tenderly-rapturous song to have been written by—*yourself!*

Well said, my dear girl! I see the dove can peck if you provoke her! returned Franklyn good-humouredly. But the truth is, with all that bitterness of spirit, and extravagant drollery of humour, which pre-eminently characterizes this celebrated Author, there is at times a strong *revolt*, as it were, in his mind, from every thing of that nature: in one moment he becomes from the most ludicrous the most pathetic, from the most indecorous the most elegant, and from the most acrimonious the most amiable, of all poets—except Shakspeare.

I thought we should have that qualification! observed the Colonel.

No better instance can be given of this serio-comic eccentricity in Aristophanes, than his ever-recurring addresses to the Nightingale, throughout the drama from which I have quoted one: his passion for that bird betrays a softness of heart and a refinement of soul which you would expect only from an Euripides,—"sad Electra's poet," as Milton calls him,—or the plaintive muse of Simonides. Again, the Bard invokes her presence by the most endearing epithets:

"O gentle bird of auburn wing!
Gentlest and dearest that doth sing,
Consorting still with mine thy lay,
Loved partner of my wildwood way!
Thou'rt come! thou'rt come!—All hail! all hail!
I see thee now, sweet Nightingale,

> Low-twittering lead thy pipe along,
> Then sudden in a spring-tide song
> Burst out the descant bold and free
> Of anapæstic minstrelsy!"

As beautiful as the former! exclaimed all.

Nearly. Observe the precision of that beautiful epithet, "auburn:" have you ever seen a nightingale? This is just the colour of its wing, a russet-olive-brown? Observe too, how the poet himself explicitly declares the natural pensiveness of his habits and disposition:

> "Consorting still *with mine* thy lay,
> Loved partner of my *wildwood-way!*"

And don't forget that most descriptive verse—

> "Low-twittering lead thy pipe along."

Nor that vision of sylvan imagery presented to the eye of your mind by this whole lyric.

What is the meaning of "anapæstic?" inquired Isabel.

It is a vile term of prosody, which disfigures this otherwise perfect little madrigal! I wish, with all my heart, the translator had been stung by a venomous spark from his own *Purgatorio* when he thought of inserting it! But such incongruity of character, (proceeded our charitable critic) as you see exemplified in Aristophanes, is by no means so rare as is generally imagined. You see what an intellectual Proteus Shakspeare was; and the Author of Hudibras himself, though perhaps more desperately given to the ludicrous than any poet that ever yet existed———

"Poet!" said Eugenia; surely you would not call the doggerel verses of that author by the exalted name of *poetry?*—Nothing that I have ever seen of his deserves the appellation, however it may have merited that of wit, or satire, or humour.

Perhaps not, replied Franklyn, with a careless toss of his head, and an abrupt interrogation,—You observe how the Moon has gradually brightened as the sunbeams have been drawn off the face of the sky? Yes; she is now lady of the ascendant. Now! now, indeed, she fulfils that description of the poet, so precisely matter-of-fact, and yet so highly imaginative:

> "The Moon pulls off her veil of light,
> That hides her face, by day, from sight:
> Mysterious veil! of brightness made!
> At once her lustre and her shade!"

You are bountiful of elegant quotations this evening! Where did you find these sublimely-poetical verses? said Eugenia fervently.

In *Hudibras!*

I will never give any opinion of an Author again! exclaimed Eugenia.

Until you have *read him through*,—at least once, which is the modern Critic's *ne plus ultra*, replied Franklyn. But is not that a most beautiful specimen of poetical *antithesis*,—" At once her *lustre* and her *shade?*" Yet it is scientifically exact! The Moon, you remember, is an *opaque* body, which only reflects the lustre of the Sun: in the day-time, however, that very lustre is so dense throughout the whole of the sky, that her reflected light is lost in his superior effulgence, which therefore may be justly described as a luminous screen or shade, a " veil of brightness," betwixt us and her, rendering her delicate splendour completely invisible.

She is, then, a happy illustration of Milton's bold expression, " dark with excessive bright," remarked Mrs. St. George.

Yes, but not exactly in the Miltonic sense of that expression; she is not dark (that is, in the Miltonic sense, *unbeholdable* or *sight-blinding*) on account of her *own* excessive brightness, but is invisible on account of the air, or ether, between us and her, being of an excessive brightness; as it is, in fact, a hemisphere full of sunbeams or luminous particles. You must clearly observe this distinction.

The Moon is, as it were (observed the Colonel in a questionary manner), buried in the sunlight which surrounds her.

I do not know, replied Franklyn. I am rather inclined to think that there is comparatively but little sunlight in her region of the sky, when it is noon with us. My opinion is, that if at mid-day we could ascend, in a balloon, to a very great height from the Earth, the sky above us would gradually become *darker*, and the stars as well as the Moon become visible.

This is a new idea! said the Colonel a good deal surprised. On what do you found so odd an opinion?

On this, replied our young Philosopher modestly yet firmly. Our *atmosphere* is the principal cause, although the *Sun* is the chief source, of all the light we enjoy. If we, then, ascended beyond the effective region of the atmosphere, we should *only* enjoy the *direct* light of the sun, and therefore be in a state of *comparative* darkness.

Pray explain your meaning. This is a most curious subject!

You must give me leave, then, said Franklyn, to preface it with a few elementary facts respecting the nature of light and air; which facts, by the by, are indispensable to students in Astronomy, and therefore you will probably hear them stated with yet more interest and attention.

Do you remember the experiment I showed you this morning with a half-crown piece and a basin, which Reginald dignified with the name of a "pretty *trick*?"

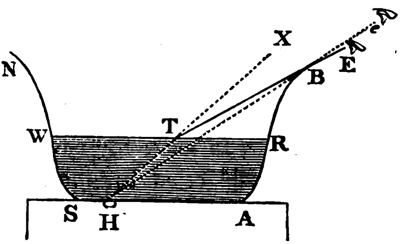
I was not present, said the Colonel, being engaged with military duty. Will you oblige me by describing it?

In the bottom of an empty basin I laid a half-crown piece, and putting the basin on a table, made every one, looking steadily at the half-crown, stoop till it was just covered from sight by the edge of the basin. I then poured in some water, when, lo! the half-crown re-appeared to the astonished gazers, although no one had moved in the mean time!

How do you explain that? demanded the Colonel.

It is satisfactorily explained in this manner:

A beam of light, passing out of a thicker medium, as *water*, into a thinner, as *air*, is always found to deviate from its first line of direction, and to take a new direction, *closer* to the common surface of the

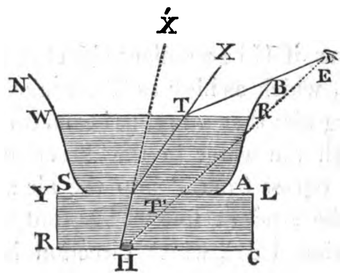


fluids. Thus, if H be a radiant object at the bottom of a vessel, which as high as T contains water, all above being air; then a ray, or beam, from H, passing through the water in the direction HT, will not, at its egress from T into the air above, continue in the straight line HTX, but will take a new direction TBE, which direction is closer to the common surface WTR, of the water and air, than the old direction TX is.

Hence, if the basin, B A S N, be at first empty, and H be a half-crown at the bottom of it, place your eye in such a position, *e*, that you can barely see H in the direction H B *e*, just touching the edge of the basin at B. Now stoop a little lower, so that your eye shall be at E; and of course H will be no longer visible. But if upon this the basin be filled to T with water, while your eye remains still at E, what will be the effect? Will not a beam from H, thrown out in the direction H T, take the new direction T B E, and so entering the eye at E, render H visible?

Certainly! This is at the same time strange and satisfactory. I will perform the experiment myself to-morrow, said the Colonel.

Do so, and doubly assure yourself of the truth I have stated. Now, to make my advantage of it in the way I proposed! cried Franklyn sketching another figure. Let the half-filled basin stand



upon a block of *crystal*, CR′YST′AL, which substance is yet denser than water; and place the half-crown at H beneath the crystal. Now, in the same manner as with water and air, a beam HT′ from H passing out of the thicker medium CR′YST′AL into the thinner SWRA, will take at T′ a new direction T′T, closer to T′L, then the old direction HT′X′. Likewise, as we have seen, in passing from SWRA, the water, into the air above, this beam HT′T will take at T another new direction TE, closer to the surface TR than the preceding direction TX. Upon the whole, then, we find that the beam from H has been, as it were, *bent* or *broken* twice, at the points T′ and T, so as to form a hollow crooked line HT′TE.

By this means, observed the Colonel, the half-crown H would be visible to the eye at E, looking over the edge B of the basin,—though it could not be seen in the straight direction HE, on account of BA the side of the basin?

Just so. Reversely: a beam passing out of a *thinner* medium into a *thicker*, is bent farther *from* the surface, instead of closer *to* it. Thus, if ET were a beam passing from *air* into *water*, it would be bent into the direction TT′, which is farther from the surface WR than ET is; and if this broken beam ETT′ passed still on from the water into the crystal, it would be bent into the direction T′H, which is further from the surface SA than TT′ is; consequently, the whole beam

ETT'H is twice bent or broken at T and T' into a hollow crooked line ETT'H, by passing out of a thinner medium into a thicker, and a yet thicker still. Now, from this *bending* or *breaking*, such a phenomenon as I have described is called *Refraction*, because, in Latin, *frango* signifies to *break*.

Ha! exclaimed the Colonel; I have often met with that word *refraction*, yet I never till now perfectly understood its meaning. By means of refraction, then, an eye at E could see a radiant object at H; or, reversely, an eye at H could see a radiant object at E?

You are speaking for me! said Franklyn. If an eye were at H, and a beam ET were thrown out from a radiant object—a star for instance—at E, this beam would make its way in the crooked path ETT'H, and so render the star visible to the eye at H, though it would be *in*visible through the side of the vessel BA.

Is not the principle which you have been explaining, asked Eugenia, one which belongs properly to the Science of *Optics*?

Yes; it is the foundation of one whole department in the Doctrine of Light, technically entitled Optics.

I have been deeply interested by the disquisition, added she; but still I cannot discern what it has to do with your theory about the Heavens growing darker, at *noon-day*, according as we got nearer the Sun. To say that as one approached the very centre of Light and Fire, rising above the vapours and cloudy exhalations in which the Earth is always immersed, even when the air is most pure and serene;—to affirm that a greater degree of splendour and illumination would not be the consequence,—this appears to me quite paradoxical!

Set it down as such, if I do not render the possibility of it as self-evident as that Sun itself at noonday; and though I do not pretend to establish my opinion as infallibly certain, I think I shall oblige you to allow that it is highly probable. You are perhaps aware that the atmosphere we breathe becomes thinner and thinner as we ascend in it. This has been ascertained beyond doubt, both by land-travellers and air-travellers. When Humboldt and his party had proceeded up Chimboraço nearly to the summit,—that is, above 19,000 feet in perpendicular altitude, and the highest that ever man has trod upon earth, respiration became so difficult, by the extreme tenuity of the air, that few of them could have gone farther, even if the chasm of 500 feet wide had not stopped them all. Aeronauts have likewise found the same inconvenience from the gradual rarefaction of the air, as they ascended in it. Nay, I have, to a slight degree, perceived it myself in many of my Highland rambles; and you too, I dare say, Colonel, have had some experience of it in the Sierras of Spain.

Ay! said the Colonel with a glisten of his greyblue eye at the military recollections excited by that name; I can bear you out so far in your theory.

Well, now, is it not plain that a beam from the Sun, striking on the outside of our atmosphere, and penetrating through it, must be gradually *refracted*, or bent, again and again, as it descends into a thicker and thicker layer of the atmosphere?

That is certainly plain enough; it will be broken continually in its descent, just as the beam ETT'H was in its descent through the water and the crystal, answered Eugenia.

Being thus broken "*continually*," as you say, added Franklyn, it will form a series of indefinitely small straight lines, so small, indeed, that, instead of a "hollow crooked line," it may rather be denominated a *curved* smooth line. Nevertheless, you see that, in the course of its descent through the atmosphere, it perpetually strikes on new particles of the air, in a perpetually varying direction. Consequently, as the light makes its way through particles so numerous, portions of it will be reflected, or thrown off, from some of them on all sides, just as portions of sunlight are reflected, or thrown off, from the particles of water whose surface you perceive to glisten or shine; and the beams thus refracted and reflected, scattered and disseminated throughout the whole atmosphere, being innumerable,—this will cause a much greater degree of light around us, than if every beam were shot straight to the Earth, and were absorbed by it immediately.

No doubt, said the Colonel; for one and the same beam may be splintered into a million of atoms by striking on so many particles of air, and each of these atoms may be refracted or reflected in a million of zig-zag directions through the atmosphere.

And thus, subjoined our Theorist, weave, as it were, a mass of luminous network to fill the air, whose threads, however, are so incalculably fine, and so inextricably reticulated, as to be separately undistinguishable by mortal vision.

I am not perfectly satisfied with this, observed Eugenia. I do not understand how the particles of air, which are themselves so small as to be invisible, should yet be able to "throw off" anything from them. Besides, were they even larger, they are so light and *unsteady*, that I should rather think a beam of light would drive them before it, than be itself driven off from them in another direction.

I like to hear your objections; and they are very ingenious, returned Franklyn who for once found himself betrayed into a compliment. Recollect, nevertheless, that, however "small" the particles of air may be, those of light are inexpressibly smaller, not being *felt* even by so tender an organ as the eye, on which they impinge, whilst the air is felt in every wind that blows, or by merely running against it. It has been established by experiment that a grain of ordinary sand is infinitely bulkier than *a million* particles of light. Recollect, also, that however "unsteady" the particles of air may be, those of light move with such amazing velocity that the former have not *time* to give way. You will hereafter learn that light moves with the velocity of nearly 200,000 miles in a second!—so that they glance off before the aerial particles on which they strike can move from their places. Besides which, a very small degree of resistance, indeed, is necessary to throw off a body which strikes *obliquely* on the resistant; as the particles of light must be supposed to do, in numberless cases, on the particles of air. But whatever you may choose to think of it, the received opinion amongst astronomers is, that a great portion of the daylight we enjoy is owing to this reflection and dispersion of the particles of light by those of air, throughout the atmosphere.

Why, I thought you told us that this was your own private theory! exclaimed Eugenia.

By no means. My theory, as you call it, is indeed founded upon this; and taking this for granted (as I believe we must), follows most simply from it. For if the atmosphere be the cause of a great portion of that daylight which we enjoy, consequently, if, as I set out with supposing, we ascended high enough, videlicet, to where the atmosphere was so thin that its refractive and reflective power was next to nothing, we should then lose that great portion of daylight, and find ourselves in comparative darkness. We should then only enjoy the direct beams of the Sun, and should not have them returned, interwoven, and scattered in all directions about us: so that now I hope you acknowledge, not only the possibility, but the probability, nay, the moral certainty, that, if exalted towards the Sun, at noonday, we should, instead of rising, as one at first thinks, into richer fields of glory, find every region of air gradually less and less brightsome, till at length the very Moon and stars would become visible.

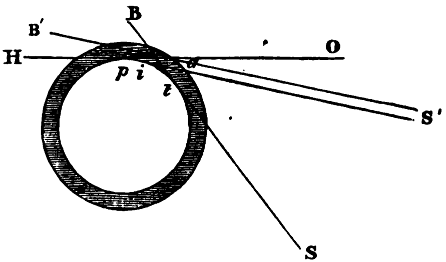
By your reasoning, then, said Reginald, when we reached the centre of light itself, it would be *pitch dark!*

Franklyn laughed heartily at this imputed result of his theory. "No, no!" said he, "although at a certain height from Earth comparative darkness would ensue, when we still rose higher so as to come near the Sun, his beams would there be so dense, or close together, as fully to compensate for the want of refraction and reflection."

Notwithstanding the interest you may have felt, continued he, in our preceding discussion, and, I may add, the knowledge you have acquired from it, I should not have thought of diverting your attention that way, if it had been altogether out of the astronomical line of inquiry. But, in fact, it is one of those bye-paths which the traveller of heaven's unknown regions must necessarily tread, if he would be acquainted with the celestial kingdom. For example, what is the cause of *Twilight?*

A portion of the Sun's rays coming to us after he has set, answered Eugenia.

Ay, indeed? after he has descended below the horizon! How can that be? exclaimed Franklyn.



Here is *p* our place on the earth *p t e*, H *p* O is the line or *flat* of the horizon at that place, BS is the ray coming from the Sun at S below the horizon, and grazing the earth at *t*. Pray how is that ray to "come to us" at *p*, when it evidently passes above our heads?

Yes, but the Sun is not to be supposed so *very far* beneath the horizon as you have placed him. This is not fair! said Isabel who burned with anxiety to catch Franklyn tripping.

"Come on, Equivocator!"—Your scruples shall be satisfied. Imagine the Sun at S' very little below the horizon. Now please to show me, Fairest of the Fair! how your argument is bettered by this supposition? A ray from S′ will graze the Earth somewhere, as at *i*, between *t* and *p*,—so will pass on above *p*,—and *par consequence*, Fairest!—

Par consequence, retorted she triumphantly repeating his words, the ray will just *tip* a spectator's head at *p*!

True,—if men were as tall as mountains! But they are not so, now-a-days, Lady! whatever they might have been in the age of Noah. Besides, in twilight, the Sun's rays do not only "tip" the top of a spectator, but his toe likewise; there is light as low as his feet. *Reflection* and *refraction* by the Earth's atmosphere, is the cause of twilight. A ray, passing in the direction S′ B′ over our heads at *p*, is bent, or refracted, after it has entered the atmosphere at *a*, into a curved line *a p*, so as to reach the Earth at *p*. A number of other beams are refracted towards *p* in like manner. A great many more, striking on the various aerial particles above and about *p*, are thrown off, or reflected, by these, in different directions; and such beams are over and over again reflected by other particles, as well as refracted in myriads of luminous threads, as I before explained; so that the space around *p* is shot through in every part by a multitude of these little glimmering darts, or splinters, as it were, of brightness. From these two causes, Twilight results, unless you choose to look upon the faint and casual beams of whatever luminaries *may* be above the horizon, as a third. This latter, however, is not, astronomically speaking, considered as a source of real twilight.

How long does twilight continue? said Isabel.

Sometimes, in these countries, from sunset to sunrise; that is, about the months of June and July. For at this season the Sun is very little below our horizon during the whole of what is called night. At the Equator twilight continues but a very short time. For there, you remember, the poles are in the horizon [page 32], and the equator stands directly over head, like an invisible bow, with its sides perpendicular to the horizon; parallel to the equator moves the Sun in his diurnal circle, and adown the western perpendicular side of this circle descends headlong beneath the horizon, so as in a short time to be completely buried with all his lustre. Where the pole is considerably elevated, and the equator is inclined obliquely to the horizon, or, in other words, at places which have some considerable *latitude* [page 39]—the Sun will descend more obliquely, and therefore be long in getting so "very far" beneath the horizon, as that his rays, like SB, should slope too high above *p*, for refraction or reflection. At such places, Rome for instance, which has about 41° latitude, twilight would be of longer continuance than at the Equator; though even at Rome the Sun would descend with comparative rapidity to what it does at London, whose latitude is 10½° more. Thus Milton, with an allusion to the Sun's position below the horizon, says of its Guardian Spirit—

> "Uriel to his charge
> Return'd on that bright beam, whose point now raised
> Bore him slope downward to the Sun now fallen
> Beneath the Azores; whether the prime orb,
> Incredible how swift, had thither roll'd
> Diurnal, or this less volúbil Earth,
> By shorter flight to the east, had left him there
> Arraying with reflected purple and gold
> The clouds that on his western throne attend."

The duration of twilight increases as the pole is more elevated, and therefore the equator more oblique to the horizon; or, in other words, as the latitude of the place increases; so as at high latitudes to be prolonged from sunset to sunrise, about midsummer, when twilight at *all* places is longest.

At what latitude does twilight *begin* to last from sunset to sunrise, about midsummer? acutely inquired Eugenia.

In places of $48\frac{1}{2}°$ latitude, or a little more northern than Paris. This phenomenon, so common in high latitudes, had somewhat the air of a miracle to the southerns. Tacitus, a well-informed and sagacious historian, in describing Great Britain says—"At the extreme parts the night is so short, that you can scarcely perceive its beginning or end. But if clouds do not prevent, it is *affirmed* that the Sun's lustre is beheld all night." What would he have said, had it been "affirmed" that still farther north the twilight lasted for nearly two months together?"

But is that actually the case? said Isabel.

It is; at the pole. Here, as the celestial pole is directly overhead, the celestial equator coincides with the horizon; therefore, when the Sun is in the intersection of the ecliptic and the equator, his diurnal circle is performed in the equator or horizon; and when he first passes into that half of the ecliptic below the equator, or horizon, his first diurnal circle is performed parallel to and just below it; his second, parallel and a little lower; his third, parallel and somewhat lower still; and so on, for many days, without getting so low as not to have his beams refracted and reflected by the atmosphere so as to cause twilight. In fact, twilight at the pole lasts nearly four months out of the twelve: for when the Sun is about to pass into that half of the ecliptic *above* the equator, at the *other* intersection, his diurnal circles are performed, like those aforesaid, so very little below the horizon that his beams are continually seen to shoot above it.

I have been looking at the figure you last drew, said Eugenia, and I cannot help drawing a conclusion from it, which seems incontestable; yet it is so very strange, and apparently so absurd, that I am almost afraid to mention it. Indeed I know I must be wrong!

Tell me what it is, and if you be wrong I will endeavour to set you right. Better be convicted of an error than remain in it; the disgrace is much less.

Well, then, I cannot help thinking, said the hesitating Girl, that if the figure be correct, we can actually see the Sun when he is *below* the horizon.

That is, shouted her thoughtless Brother with a schoolboy's love of ridicule, we can see the Sun when he is out of sight!

Your conclusion is perfectly just, Eugenia, said Franklyn, and Reginald's laughter is marvellously out of place. The beam S′ *a p* reaching a spectator at *p*, must of course render the Sun visible, although he is beneath the horizon; and I give you great credit for your penetration, in discovering by your reason a fact which is confirmed by experience. A spectator at *p*, sees the Sun in the direction of the ray as it enters his eye; and this direction is, as you perceive, that of the curve *a p*, at its end next *p*, so that this end *rising* from *p*, above the horizon, while the other end *falls* towards S′ below the horizon, the Sun must appear to be elevated above the horizon, when he is actually situated below it. You are not, however, to be so far misled by the figure, as to suppose that the Sun can be seen when much below the horizon. In fact, when his uppermost edge is more than about the breadth of *his own disc* below the horizon, none of his beams can come like S′ *a p* directly to *p*, and therefore no part of his disc can be visible. And in order that his whole disc should be visible, when he is below the horizon, its uppermost edge must about touch the horizon.

Then, in truth, remarked Eugenia very acutely, refraction can only elevate the Sun about the breadth of his own disc.

You are a clever girl! exclaimed Franklyn. Exactly so. And to elevate him even thus much, the atmosphere which refracts must be very dense, and all circumstances must be favourable. Now, the atmosphere near the horizon is always, you know, most dense; and therefore refraction is greatest when the Sun is in or near the horizon: this is called the *horizontal refraction*, and is just about great enough, as you say, to elevate the Sun his own breadth in the sky. When he is half-way up the sky, refraction does not elevate him a thirtieth part of his breadth.

I must now beg leave to make an acute remark, said Isabel, that *I* may be called "clever girl," as well as Eugenia. When the Sun appears to be above the horizon, but just touching it with his lower edge,—

> "With wheel just hovering o'er the ocean brim,"

as somebody says,—we may conclude that he is, in truth, really below it.

Excellent again! You may, indeed, said Franklyn much gratified; for as horizontal refraction elevates him, in appearance, his own breadth, he is, at the time you speak of, really lower by his own breadth than he appears, that is, he must be actually below the horizon.

> " So when the Sun in bed,
> Curtained in cloudy red,
> Pillows his chin upon an orient wave,"

Not only his chin, but his whole head (and he is *all* head) must, by the rule of refraction, actually be sunk in his orient pillow, whatever may appear to the contrary.

All the other luminaries are affected by refraction, I suppose, as well as the Sun, observed Colonel St. George.

Certainly; they are all elevated, or rather appear to be elevated, by refraction; but in a less and less degree, as they are really higher in the sky. In astronomical calculations, therefore, we have generally to *allow* for refraction, or to correct our operations and results by its quantity, in order to obtain what is true from what is apparent: this is technically denominated a *correction*, and there are many other *corrections* used in this science, the principal of which I will acquaint you with.

I have often remarked, said Mrs. St. George, a very odd appearance in the Sun and Moon when they were very near the horizon: instead of being perfectly *round*, they are *oval*: can this have any thing to do with refraction?

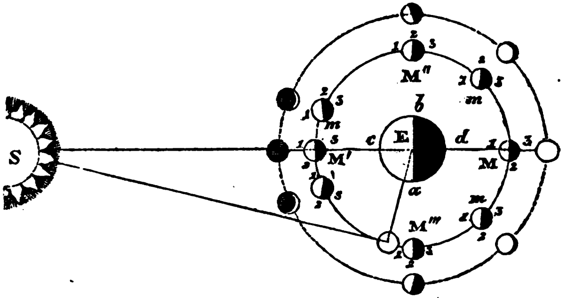
Refraction has every thing to do with it, replied

Franklyn. You have seen that refraction is greater according to the densities of the atmosphere causing it: wherefore, as the atmosphere is denser according as it is nearer the horizon, refraction must elevate the *under* edge of either Sun or Moon, more than it elevates the *upper* edge. [See Engraving at the head of this EVENING.] By this means the circular form of these luminaries is spoiled, and while the under semi-circumference *a d c* is flattened by its middle point being more elevated than its extremities *a*, *c*, the upper semi-circumference *a b c* is flattened by its middle points *m b n*, being less elevated than its extremities *a*, *c*, so that on the whole an oval figure, *a b c d*, is the consequence. It is not *perfectly* oval, however, that is, the two parts *a d c*, *a b c*, are not exactly equal and symmetrical, because the former, being lower, is more affected by refraction, *i. e.* is more *flattened*, than the other.

Let me just add, continued he, before we are driven to fold,—that it is from the principle of refraction we conclude the Moon to have little or no atmosphere; for when a star was really covered by her edge, we should yet be able to see it, if her atmosphere there were dense enough to refract its rays,—just as we should see it when really below our own horizon. Let me likewise superadd this, for the Colonel's special information: it is by refraction that we are enabled to see the Moon when she is totally eclipsed. A great many of the Sun's beams which graze the sides of the Earth, are bent round it by the refractive power of its atmosphere, into the conical shadow, so as to mitigate or scatter the darkness within that shadow, to reach the Moon, and to give that gloomy, dun, copper hue to her orb, of which you were solicitous to know the reason. Thus [see the Engraving at the head of EVENING VII.] if *o a*, or *n e*, be the height of the Earth's atmosphere, all sunbeams coming between *o* and *a*, *n* and *e*, are refracted; and passing behind the earth, tend to lighten the shadow, or give it a brown hue, within *v* and M, *x* and M. But there is a space behind the Earth, videlicet: *o* M *n*, into which no rays are refracted, and this is the only *perfect* shadow of the Earth, from which *all* light is excluded.

I am satisfied, rejoined the Colonel; "so now to supper with what appetite we may."

One word about the *Penumbra*, said Franklyn, for Eugenia. At M a spectator could only see the refracted beams of the Sun; but at *v* or *x* he would see the direct beams from its edge A or B; farther still from M than *v* or *x*, he would see more and more of the Sun's direct beams; and at a certain distance farther from M he would see all that were thrown out from the solar disc. Till this, however, he would not see *all* those beams; and would, therefore, be in comparative shade, which is called the *penumbra*. [See page 176.]



EVENING TENTH.

Pray, Mr. Philosopher! said Eugenia looking out from the Birdcage, and calling, in her sweet-toned voice, to Franklyn, who had stood for a long time, half way down the esplanade, with his back to the party—Pray, Mr. Philosopher! if your divine contemplations have not quite exalted you above all sublunary matters, be pleased to remember that coffee is on the table!

Verily, said he turning quickly, I am not so profoundly steeped in forgetfulness but that I shall dip my whiskers in a cup of that nectareous beverage! Reginald, be polite to your guest, and put about the confectionary!

So saying, he loaded his saucer all round with spunge-cake, plum-cake, biscuits of all denominations, &c. &c., and securing a handful of others, walked out of the bower to his old place, muttering, as he went quaffing and munching along—

"Spare fast! that with the gods doth diet"—
"The feast of reason and the flow of soul!"—
"The fruits his food, his drink the crystal well!" &c.

What can he possibly find so attractive there! said the Colonel, rising, and following him, being himself followed by all but his Lady, who however remained only to sip one cup of "elemental tea," and then quietly joined the others.

What are you looking at with such prodigious intensity? demanded the Colonel of his nephew.

What I have ever regarded, answered Franklyn, as one of the most delicious prospects on which the eye can feed!—Rose-bud! fetch me a cup of Cathaian nectar, said he, (speaking in his every-day voice to Isabel); "the most delicious," as I was saying—"the most delicious—"

Rosebud returned with the beverage. [This, notwithstanding the learned title of *Cathaian nectar* usually given it by our pedantic gentleman, was nothing in the world but that most common domestic fluid—*tea*, which he so christened from its mother-country, China, or Cathay.]

You are the Hebe of Arbour-hill! exclaimed he taking the cup from her—and as such I will celebrate you in my next Sonnet!—

> "Oh, you are fairer far
> Than the chaste-blushing Morn, or that fair star
> Which guides the wandering seaman o'er the deep!"—

by the said fair pilot star, if our poet means the *Moon*, there she is!

O now we can explain your lunatic behaviour, said the Colonel.

I confess, replied Franklyn, that I do love to behold

> "Gray-hooded Even
> Like a sad votarist in palmer's weeds
> Rise from the hindmost wheels of Phœbus' wain,"—

especially when he has such a torch-bearer as this to light him on his heavenly pilgrimage.

It is not "dichotomized" to-night, said Isabel pronouncing the word with some difficulty.

Which do you mean? Hesper or Hecate?

I mean the Moon, Mr. Wrangler! answered the Hebe of Arbour-Hill. She is not so large as she was last night.

She is every whit as large! retorted he, only that *you* can't see the part of her orb now in darkness. Her visible *disc*, I grant, is less than it was last night, though very little.

Well, her "visible disc," if I must be so very mathematical! said Hebe. She is now only a crescent.

Wrong again! exclaimed the hypercritic. She is not in the *crescent*, but in the *wane*.

A distinction without a difference!

Pardon me, Signora!—The Moon is, properly speaking, in the crescent when she is *increasing* towards the *full;* in the wane, where she is *decreasing* towards the new Moon. Let us examine this point, continued he, a little more curiously.

You know what enormous wax-candles are used in Catholic churches; suppose there be one of these as tall as yourself, standing at some distance lighted behind you. Suppose that I hold a ball of white ivory exactly *before* your eye at a less distance: it is plain that you will see nearly one-half of the ivory ball illuminated, namely the half presented towards you, while the farther half is in darkness. Now let Eugenia paint a black line round the ball, as I thus hold it, just along the boundary of the light and dark halves: will not this be the *circle of light and darkness?*

Yes, we may consider the ball as a *little Moon*, said Isabel, whilst *I* am the Earth, looking with all my eyes at it.

And the flame of the wax-candle is the *Sun*, added Eugenia.

And if I hold the ball, superadded Franklyn, with my forefinger at the uppermost and my thumb at the lowermost point, these two points will be the *poles* of the little Moon; or at least nearly so, as I told you her axis was nearly upright. Here then we see that when the ball and flame are *opposite* each other, with respect to you between them, all of the former presented towards you, namely one-half, is illuminated: in like manner, when the Moon and Sun are opposite each other, with respect to the Earth between them, all of the Moon, presented towards the Earth, namely one-half, is illuminated. In order, briefly, to express this relative situation of the three bodies, let us say that upon such occasion the Moon is *in opposition* to the Sun, or more briefly yet, that the Moon is *in opposition.*

When the Moon, therefore, is in opposition, as you say, she must be what is called *full,* remarked Eugenia.

Precisely. When the Earth is between her and the Sun, her illuminated half is presented full towards the Earth, or, in other words, her illuminated apparent disc is a *full circle.*

Suppose now, that with the ivory Moon between my finger and thumb, I walk half round you to the flame, keeping all the while at the same distance from you as before: how much of the ball will you now see?

Very little, indeed, said Isabel, until you get out of the way!

Well, suppose I do get out of the way, said Franklyn smiling, and only hold the ball between you and the flame, how much of the former will you see?

Why, just as much as before, only that it will be now the *dark* half instead of the *light* one.

Hence, when the Sun and Moon are in this position with respect to the Earth,—

There will be an eclipse of the Sun, added Isabel, concluding his sentence.

True, or an obscuration. But this will only happen if any part of the Moon come exactly between the Earth and any part of the Sun; in other words, when either of her *ecliptic limits* are in that position. Otherwise she may come nearly between the Earth and Sun, without causing such a phenomenon.

Yes, "*nearly*," just as you might hold the ball a little on one side of the candle, without eclipsing or obscuring the flame; but then I should see a *leetle* of the illuminated half, at the side next to the flame.

And of what *shape* would that "leetle" illuminated part be? inquired Franklyn.

The edge next the flame would be circular, the shape of the ball itself; and the enlightened part which I should see within that edge, would be— would be—pooh! I can't tell you!

Franklyn while he chuckled inwardly at the comic *naïveté* of this answer, proceeded to explain:

Can you not perceive that it would be shaped like the internal curve of a *crescent*, and that in fact the whole little illuminated part would appear like a crescent?

No, indeed! for a crescent is *flat*, while this illuminated part is protuberant, rejoined his fair Pupil anything but submissively.

Wel' but, my dear girl! if the ball were so far from you as to appear flat like the Moon, would not this protuberant part appear flat likewise?

O now, indeed, I see! This, then, would represent the new Moon?

Rather the *old*, for she is now about to disappear. Suppose I move the ball from that side of the flame, in a direction either above or below the flame (but not crossing it), as far to the other side: what shall you see now? asked our cross-examiner.

The same kind of crescent as before, answered the witness, only that it will be now on the *other* side of the ball, namely, that next the flame.

Here, indeed, you have a representation of the *new* Moon, said he; for when the ball was passing exactly above or below the flame, you could not see even a "leetle" part of the illuminated half, which was then turned wholly from you. In like manner, when the Moon is passing between us and the Sun,—or when she is passing directly above or below him,—her illuminated half, being turned wholly from us, is invisible, and the Moon is then at her change from old to new, or in common phrase there is *no Moon.*

The Moon is at her change then, said the Colonel, when she and the Sun are closest together?

Yes, if you mean, by that expression, when the width between their centres, measured by an arch of the concave surface, is least in each of her revolutions. In this sense of the word, it may be said that the Sun and Moon are *together*, although the Sun is *really* so many miles behind the Moon, and although she may be a little above or below him, on account of her orbit being inclined to his. We may therefore denominate this position of the Sun and Moon, as viewed from the Earth, for brevity's sake, *conjunction;* and when the Moon and Sun come together, as above described, we say that the Moon is in *conjunction*,—meaning in conjunction *with the Sun*, as viewed from the Earth.

When is she "in her quarters," as the Almanacs say? demanded the Colonel.

That I am just about to explain. Suppose, after the ivory ball being "in conjunction" with the flame, I move it onwards: then, as Miss Hebe told you, we should see a little of the bright half, bounded on the side next the flame by the circular curve of the ball, and spreading fainter and fainter from that edge towards the dark side of the ball: At what point of the illuminated edge, between my finger and thumb (the two *poles* remember), would the *breadth* of this illuminated part be greatest?

Would it not be all the same breadth? said Isabel hastily.

Foolish girl! how could that be? It would evidently be broadest at the *middle point* of that edge between the said poles, broadest in the direction of its *equator;* that is, of a belt equally distant from my finger and thumb. This breadth would gradually diminish on each side of the belt, or equator, till it vanished in a point at each pole, or just under my finger and thumb.

Why, the inner boundary of this bright part is so confused and indefinite, that we can hardly form an idea of it, remarked the Colonel.

It is so, admitted his Nephew; but if the ball were very large, very distant, and very strongly illuminated, as the Moon is, that boundary would become much better defined, and would appear on the dark surface, stretching from pole to pole, in a rugged curve line, such as we observe to form the less bold and brilliant edge of a crescent. This bright part of the ball, then, would be broadest exactly half-way between my finger and thumb, narrowing gradually into nothing at the poles; wherefore, at a great distance, when it appeared flat like a crescent, its two polar ends would appear like two hook-pointed blades. These, on the lunar crescent itself, are called *horns*, from their bended figure, as Young Norval insinuates;

> "The Moon, which rose last night
> Round as my shield, had not yet fill'd her *horns*."

If she were "round," as the ordinary Caledonian shield is, said the Colonel, I do not see how the poet could with any sort of propriety talk of her *horns*. If, indeed, Norval were equipped with a crescent-shaped "moony shield," such as was borne by the Amazons of old, the simile would be strictly correct, and beautifully so into the bargain.

You perhaps forget, sir, replied Franklyn, that by this expression he does not refer to "last night," but to a fortnight before, when the Moon was at her change. The horns of the Moon are otherwise denominated *cusps*, from *cuspis*, the Latin for a a *spear-point*.

The pointed horns of the Moon, of course, grow more and more blunt, as she grows older and older, said the Colonel.

Yes, said Franklyn, until she becomes full, when her horns disappear in the perfect rotundity of her countenance. Thus, suppose me to carry our little ivory moon farther from the flame, yet keeping the same distance from Isabel, who stands in the centre of the circle round which the ball is moving, she will continually see more and more of the illuminated half.

Yes, added she, for whilst I thus stand, like "fool in the middle," I can see, as it were, more *round* the illuminated half of the ball, the farther it proceeds from *conjunction*, where, like Franklyn rather than Chesterfield, it most unceremoniously presented its back to me.

Well! said Franklyn; now suppose the ball to have proceeded about *half-way* round from conjunction to opposition again, where I first held it, would not the circle of light and darkness on the ball, which always presents its *flat* to the flame, now present its *edge* to Isabel?

Let us consider that, said the Colonel. She continually sees more and more of the half presented full to the flame, that is, the boundary between this half and the half presented full to her continually encroaches on the dark part, until at length she sees exactly one half of this illuminated half; that is, one *quarter* of the whole globe.

In other words, remarked Eugenia, of the half, or *two* quarters, presented full to Isabel, one is bright, and the other dark.

Thanks for that most perspicuous statement! cried Franklyn; I needed it. Therefore (demanded he), therefore, is not the boundary dividing the light from the dark part, and reaching from pole to pole, or from finger to thumb,—is not its *edge*, I say, exactly between Isabel and the centre of the globe?

If my arm were long enough, replied she, and the ball soft enough, I might cut through the circle of light and darkness to the very centre of the globe, merely by stretching a knife out before me as I looked at it.

Yes, if you cut sharply enough,—which you can do upon occasion, as I know to my cost, added

Franklyn. The circle of light and darkness, then, having its edge to Isabel, would at a great distance, when she could not see that it was protuberant, appear like a flat straight line dividing the flat disc of the ball into two semicircles, one light and the other dark. Just so with the Moon! At her distance we cannot see that her body is globular; it appears flat, and the circle of light and darkness on its surface appears flat likewise. This circle seems to be only a very little within the bright edge of the Moon, a few days after her conjunction with the Sun, when she is said to *change;* and forms with that edge a beautiful crescent, denominated the new Moon. Every day, as the Moon increases her width from the Sun, this circle increases its breadth from the said bright edge, till at length it appears to form a straight line down the middle of her face, where its edge is exactly presented to the Earth.

She is, therefore, now in her quarters? said the Colonel.

In *one* of them; in her *first* quarter, replied Franklyn. When she has gone through opposition, where she shines with a full face, and approaches conjunction till she is as near it on the other side of her orbit as she is now on this, she is then in her *last* quarter. Quarter is sometimes called from its Latin root *quadrature*.

O! it is plain, remarked Eugenia, that she will exhibit the same appearances at the same distances from conjunction, or opposition, whether she is receding from, or approaching to, conjunction.

With this slight difference, subjoined Franklyn, —that if she be receding from conjunction, her "horns" will point *forward*, or in the direction in which she is moving, while, if she be approaching conjunction, they will point backward, or in the direction contrary to that in which she is moving.

That is, said Eugenia, the horns of the *new* Moon point the way she is moving, while those of the *old* point the opposite way to that in which she is moving.

Yes; and as she always moves in her *orbit* from West to East, this fact we have specified will serve to distinguish the new Moon from the old, even when their shapes are exactly similar. For if the horns point to the *East*, that being the same with the direction in which she is moving, we know it must be a new Moon; if they point to the *West*, that being opposite to the direction in which she is moving, we know it must be an old Moon. And, indeed, the same rule will tell us whether she is in her first quarter or her last; as also whether she is approaching opposition or receding from it. In a word, it will tell us whether she be in the *new* half of her orbit, moving from conjunction to opposition, or in the *old* part of it, moving from opposition to conjunction. Don't forget this rule; it enables any one to tell the Moon's age by merely looking at her.

How is that to be done? said Isabel with as much surprise as if he had proposed enabling any one to tell *her own* age by merely looking at her.

Surely it is manifest! replied he. The Moon setting out from conjunction with the Sun is about 27 days 7 hours in reaching the same point of her orbit again [page 158]; and as the Sun has in the interim moved onward, she has also to move onward from this point till she overtakes him, in order to be in conjunction again. Hence, from one conjunction to the next occupies about 29 days and a half: so that as she moves pretty equably throughout her whole orbit, from conjunction to opposition is about half this, *i. e.* something more than a fortnight, as also from opposition to conjunction. Again from conjunction to the first quarter is something more than a week, as also from the first quarter to opposition, and from opposition to the last quarter, and from the last quarter to conjunction again.

Stay, my good Sir! cried Eugenia: you forget to prove that when the Moon came to her first quarter, she was exactly half-way between conjunction and opposition.

Yes, said Isabel maliciously hearking in—I observed him endeavouring to skip *that!*

This is the fruit of teaching others to be as wise as oneself! exclaimed Franklyn in affected misery. Why, the truth on 't is, I do *not* very well know how to prove it to you, unacquainted as you are with geometry.

"Geometry!"—That is the way he always gets out of his difficulties! cried Isabel. Whenever he doesn't know how to answer a question, he puts it off by looking very profound, and lamenting our ignorance of geometry!

I declare I think he has great forbearance, said Mrs. St. George, to suffer your *badinage* without reply or resentment. You are very ungrateful to him for all his instruction!

Each Girl taking Franklyn by one of his hands, without saying a word as they looked in his face, expressed with their eyes a wistful hope that he had not been offended by their unkindness. He attempted to deceive them at first by an appearance of silent indignation: but all would not do! They saw he was dissembling, and by dint of smiles drew the whole secret from him in a hearty fit of laughter. Then, suddenly becoming serious—

Look at this sketch, said he, [drawing one so clumsy that the ENGRAVING at the head of this chapter has been substituted for it]: suppose S the Sun, E the Earth, M, M′, M″, M‴, &c., the Moon, revolving in her orbit, of which E is the centre. You must conceive yourself as looking directly down on the Moon's orbit, which has *sliced* both her and the Earth through their centres into hemispheres; and that the circles which I have drawn to represent the Moon and Earth, are only the *faces* of those hemispheres which lie *under* the orbit.

In fact, said Eugenia with her usual clearness, that we are looking down on the *poles* of the Moon, and that those little circles are her *equator*, through which she has been, as you express it, "sliced" by her flat orbit.

Pretty nearly so, but not precisely, answered Franklyn; because you know her poles are not *exactly* perpendicular to her orbit, neither is her equator *exactly* in the same plane or *flat* with her orbit. The difference, however, is so small, that we may neglect it for the sake of simplification. Well then! If the Moon be at M opposite the Sun, with respect to a spectator on Earth, she is said to be *in opposition*; and the Sun shining fully upon her, in the direction SEM, her illuminated half, is presented wholly to the Earth; whence she appears bright from one side to the other, and from the pole above to the pole beneath the orbit: consequently at M, the Moon is *full*. At M′, when the Sun and Moon appear to a spectator upon Earth as if they were close together, the Moon is said to be *in conjunction*; and her illuminated half, you see, is wholly turned *from* the Earth, whence she becomes invisible: consequently at M′ she is *changing*.

If, however, said Isabel cavilling a little, either of her *ecliptic limits* be at M, when she is in opposition she will be *eclipsed*, instead of being full; and if either of her nodes be at M′, when she is in conjunction, she will eclipse the Sun, and therefore, as you yourself told us, be visible like a dark iron plate on his disc.

True, replied Franklyn; but recollect that, in the first place, these peculiar situations of the nodes seldom happen; and, in the second place, that eclipses continue but for a very short time, and therefore can hardly be said to prevent the Moon being full at opposition, or invisible at conjunction. Now, pray, do not interrupt me again, unless you have something very material to announce! When the Moon, revolving towards M′, &c. is at *m*, a little before conjunction, her enlightened half *m* 12 is almost wholly turned from the Earth, a very small part of the half 1 *m* 3 turned towards the Earth being illuminated, viz. the part between *m* and 1. When she has passed about as far to the other side of conjunction, about the same quantity of her enlightened half will be seen from Earth, viz. the part between 1 and her dark half now turned almost wholly towards E. At *m*, therefore, she was the *old*, and now she is the *new* Moon *. Here, however, let me observe that, in common parlance, *new* Moon is frequently taken to signify particularly the *first appearance* of the new Moon. Well!—the Moon proceeding in her orbit towards M again, and the size of her crescent augmenting daily, one half of her enlightened half, that is, one quarter of her whole globe, will at length become visible at the Earth. But it is clear enough, even without the aid of "geometry," that this must take

* The outer circle of Moons represents the *old, new, full* Moon, &c., as she appears in the Heavens.

place about M''', when the circle of light and darkness M''' 2 on the Moon, is in a line with a similar circle *a b* on the Earth. For, now the Moon's diameter 13 runs parallel to the Earth's *c d*, and now therefore the Moon must be divided, by this diameter and her circle of light and darkness, into four quarters, M''' 1, 12, 23, 3 M''', just as the Earth into four quarters, *b c*, *c a*, *a d*, *d b*, by *her* diameter *c d* and *her* circle of light and darkness. Of the four lunar quarters, however, two, M''' 1 and 12, are illuminated, and of these but one, viz. M''' 1 is seen from Earth, to which the half 1 M''' 3 is presented. Consequently, at M''' the Moon is in her *first quarter*. Is it not plain, however, that this very point M''' is midway between M' and M, or between conjunction and opposition?

Certainly! replied he to his own question. For suppose the radius E M' to move round the Moon's orbit, carrying the Moon at its end M'; when the Moon at this end came to M''', the radius itself would lie in the direction E *a* M'''; and as the circle *b c a d* is quartered at *b*, *c*, *a*, and *d*, *c a* must be equal to *a d*, so that E *a* is midway between *c* and *d*, or which is the same thing, E *a* M''' is midway between M' and M. Are you now satisfied that the Moon in her quarters is half way between conjunction and opposition?

Perfectly! perfectly! answered both Eugenia and Isabel. She is exactly midway between M' and M.

See now what clever people you are! exclaimed Franklyn. The Moon, after all, is *not* "exactly" midway between conjunction and opposition when in her quarters: but she is sufficiently near that point for our purposes *. Now, will you grant me that from conjunction to the first quarter is something more than a week, and from that to opposition, from opposition to the last quarter, and from the last quarter to conjunction, each about the same also?

Why, yes, replied the Colonel,—as the quarters are half-way between conjunction and opposition, while the whole period between conjunction and opposition, or between opposition and conjunction is about a fortnight.

I submit, therefore, rejoined Franklyn, that there remains no great difficulty in telling the Moon's age from her appearance. First, by your rule [page 246], find out whether she is in the *new* or the *old* part of her monthly period; that is, whether she is in her first fortnight or her last; then if she be less or greater than a half Moon, you can determine whether she has past her quarter or not; that is, you can determine in what *week* of her period she is. And finally, it will be no hard matter to determine, from her appearance, how

* If two straight lines be drawn from E and S, so as to meet in a point on the Moon's orbit, and be there *perpendicular* to each other (as represented in the Engraving),—*this* point is the *exact* place of the Moon in her quarter.

many days of this week have past, as in about seven the circle of light and darkness moves over half her face.

For example, how old is she at present? inquired Reginald.

About 17 days, replied Franklyn, after some consideration. For you see her horns are turned westward, and therefore we know she must be in her last fortnight. Likewise about three-quarters of her whole disc is illuminated, and therefore she must be between full and her last quarter, or in the third week; that is, she must be more than 14 days old, and less than 21. Finally, as the circle of light and darkness on her surface is about half-way between her dark edge and the line of *dichotomization* [page 157], she must be about half-way in that week, or about 17 days old.

Yes, but Franklyn, said Eugenia, it would be very hard to tell her age by this method with any degree of nicety, on other occasions.

Nay, almost impossible! To calculate her age with precision, is one of the nicest problems in the Almanac. She is not always a week in each of her four divisions, just mentioned. For example, in July of this year, new Moon happens on the 1st of the month, and first quarter not till the 9th; full Moon happens about a week after, *viz.*, on the 16th, last quarter on the 23d, and new Moon again on the 30th; nevertheless her whole period between conjunction and conjunction, which period is called her *lunation*, is about $29\frac{1}{2}$ days, and by dividing it into four smaller periods of about a week, we may often supply the want of an Almanac, with respect to the Moon's age, as I have described. By the by, it is a curious circumstance, that from M''' through M to M'', that is, when the Moon is in that part of her orbit *farthest* from the Sun, she yet affords us *most* light, and from M'' through M to M''', that is, when in the part of her orbit *nearest* the Sun, she affords us *least* light. In the former half of her orbit she is *once* full, and always more than half-full; or, as it is called, *gibbous*, from the Latin *gibbus*, protuberant or convex, (because the bright part swells out towards the dark part, instead of the dark part swelling into the bright part, as when she has the form of a crescent).

After she has passed M''', of course, we see more of her enlightened part than the half Moon, because she is getting more opposite the Sun, remarked Mrs. St. George.

Yes; for example when between M''' and M, that half of her 3 *m* 1, which is presented to us, contains a great portion of the enlightened part, namely, that between *m* and 1. After she has passed M, we, indeed, see less of her enlightened part than when she was at M, but still we see more of it than the half-moon, to which she gradually diminishes as she approaches M''. Thus between M and M'', about the same breadth of her enlightened half is seen from Earth, and for the same reason as before. You now perceive the reason of that quick and continual variation in the Moon's appearance, by which she is thought so happily to illustrate the inconstancy of her sex. Should you wish to introduce the learned name for these different faces occasionally in conversation, they are called *phases*, —a Greek word identical with the English, but possessing the advantage of not being so trite and intelligible.

Now who is guilty of badinage? said both our Nymphs.

I assure you I was never in my life more serious, replied he: most persons now-a-days enter into discourse, not to convey knowledge, but to impart confusion. Even treatises, written professedly to instruct, seem as if they were really composed to distract: for instead of converting what is obscure into what is plain (which is the whole secret of instruction), by the use of simple language, they often convert what is plain into what is obscure, by means of technical or pedantic terms, that divulge nothing but the folly of the author.

For example, said Isabel, a certain Gentleman, who shall be nameless, asked me once upon a time whether I spoke of "Hesper or Hecate;" and it was half an hour before I found out that the latter of these "pedantic terms" meant, "in simple language," only the Moon! As for Hesper, I cannot think what this is the Greek for, unless perhaps the *Sun.*

Dear Isabel! exclaimed Eugenia while Franklyn held his handkerchief to his mouth, have you never met with Milton's often quoted description of Evening?

> "Hesperus, that led
> The starry host, rode brightest, till the Moon,
> Rising in clouded majesty, at length,
> Apparent queen! unveil'd her peerless light,
> And o'er the dark her silver mantle threw!"

Yes, said Isabel looking down with a mixture of archness and humility,—but—in fact—I never exactly knew what "Hesperus" meant either!

The Evening Star, Child! said her Father. Every one knows that Hesperus is the same as Venus.

Indeed! cried the Girl; I thought Hesperus was surely the name of a *man!*

Venus is not always the Evening Star, observed Franklyn, inasmuch as she is sometimes to the westward of the Sun, and consequently sets before him. Jupiter, who next to her is the most splendid of all the planets, often takes her place as Evening Star; and as *he* is a "man," I suppose Isabel would have no objection that the name Hesperus should be applied to him. Hesper is in fact the same as Vesper, and Evening derives its name of *vesper-*

time, from being generally introduced by this star. Thus the poet eloquently sings,

> "How dear to me the hour when daylight dies,
>   And sunbeams melt along the silent sea;
> For then sweet dreams of other days arise,
>   And Memory breathes her *vesper* sigh to thee!"

From this again the Evening *Service* derives its catholic name of *Vespers:* and, by a strange association, one of the most impious deeds recorded in history, the massacre of 8,000 French at Palermo, acquired the pious title of "*Sicilian Vespers*," from having been perpetrated at an hour when religion had disarmed all but the assassins.

Can you tell us what the name Hesper itself is derived from? inquired Eugenia.

The *Lexicons*, or Greek Dictionaries, tell us—from the words *Eōs*, morning or bright part of the day, and *peras*, the end: because evening concludes the day. By the by, this would rather prove that the *star* derived its name from the *time*, than the time from the star; for it is not the star which is the end of day, but evening. In like manner we find that Evening gave its name to countries situated *West* of Greece; because the Sun setting in the west, Hesper, or as Milton descriptively calls it—"gray-hooded Even," seems to arise from thence, or, in poetical language, "from the hindmost wheel of Phœbus' wain."

Do you allude to Italy, said Eugenia, which I believe was sometimes called *Hesperia?*

Yes; and to *Spain*, and to the *Gardens of the Hesperides*, which latter were situated on the *modern coast* of Africa, near Mount Atlas, or *Cape Verde*,—if they were not rather the *Fortunate Isles* themselves, now designated by a much less romantic title *the Canaries*, and more remarkable for their grapes than their golden apples. *Sierra Leone*, farther to the south, would hardly answer Milton's description as well:

> "Hesperian gardens, on whose banks,
> Bedew'd with nectar and celestial airs,
> Eternal roses grew, and hyacinth,
> And fruits of golden rind; on whose fair trees
> The scaly-harness'd Dragon ever keeps
> His unenchanted eye! Around the verge
> And sacred limits of this *Blissful Isle*
> The jealous Ocean, that old river! winds
> His far-extended arms, till with steep fall
> Half his waste flood the wild Atlantic fills."

But we have lost ourselves in this wilderness of sweets! Hesperus is, then, a name for the Evening Star, be it male or female, Jupiter or Venus. These very planets, however, are in their turn sometimes *Morning Stars* (that is, when they rise a little before the Sun); and then Hesperus is changed into *Lucifer*, a Latin word which signifies *light-bringer*, from *lux*, light, and *ferre* to bring. *Phōsphorus*, a Greek name of the same import (from *phos*, light, and *pherein*, to bring), is another title which they adopt; but I can perceive no necessity for the latter *alias*;

and, indeed, Morning or Evening Star is good enough for a plain man like me,—except in poetics.

We have, however, learned the meaning of *phosphorus* from it, said Eugenia with much satisfaction.

Now pray give us some good reason for calling the Moon *Hecate*, said Isabel: I thought Hecate was only a pet name of Pluto's for his wife Proserpine. Shakspeare, I remember, makes her Queen of his Witches, which is quite in keeping with Proserpine's character.

Perhaps you are not aware that Luna, or Diana, and Proserpine, or Hecate, are one and the same deity in different persons? said Franklyn. As Proserpine, this Goddess was Queen of the Infernal Regions, whence she is sometimes called the *Infernal* Juno: as Luna, she is Queen of Heaven: and as Diana, she is Queen of Groves and the Chase. The appellation Hecate, which is vulgarly associated with her infernal attributes, rather belongs to her in her celestial capacity; for it simply means *far*, or *far-darting*, with an allusion to her distance, or to the radiation of her beams. Thus her brother Phœbus is similarly designated—*Hecatos*, with a similar allusion. I am disposed to think that this radiation of beams, or emission of polished darts, as it were, from both the Sun and Moon, Phœbus and Phœbe, was the origin of their mythological characters, as God of the Bow and Queen of the Chase.

With respect to her, said Eugenia, might it not have been the bow-shaped form of her crescent? Juliet, you remember, wishing to imagine that the unwelcome light of dawn is only moonlight, tells Romeo that it is but "the pale reflex of Cynthia's *bow*."

Yes, added Franklyn, and she is addressed as "Goddess of the Silver Bow," which seems to favour your idea. But however this may be, her name Hecate is most appropriately used when she undertakes the second of her three royal functions: at least so Robin Goodfellow appears to think;

> "We fairies that do run
> By the triple *Hecate*'s team,
> From the presence of the Sun,
> Following darkness like a dream!"

Here the Moon is called Hecate in preference to any other of her names, and by one of her own running footmen! Observe, however, that although it is in this place, as in many others, a *dis*syllable, it is properly a *tri*syllable, *Hecaté*. Thus Milton describing Comus,—

> "He and his monstrous rout are heard to howl
> Like stabled wolves, or tigers at their prey,
> Doing abhorred rites to Hecaté
> In their obscured haunts of inmost bowers."

For as crimes and all illegal practices are usually perpetrated at night, and with most convenience on moonlight nights, Hecate is celebrated as the patroness of witches, wizards, assassins, burglarers, and highwaymen, "under whose countenance we *steal*," says Falstaff to Prince Henry.

After having stood so long under her influence, are you wizard enough to tell what o'clock it is? demanded the Colonel looking at his watch.

Yes, I think she will enable me to do so much, or she is not worth the worshipping! replied Franklyn turning his face to the *polestar* and then wheeling exactly half round.

What in the name of wonder is he about? said Isabel. What mystical ceremony is he performing? I never knew he was a *conjurer* before!

What! do you forget my title and character already?

> "A cunning-man, hight Sidrophel,
> That deals in Destiny's dark counsels,
> And sage opinions of the Moon sells!"

She now informs me that it is about *a quarter past ten* o'clock.

I declare he is right within a few minutes! ejaculated the Colonel to the amazement of all around.

How did you do that? Dear Franklyn! Ah! Franklyn? were the eager exclamations of his younger companions.

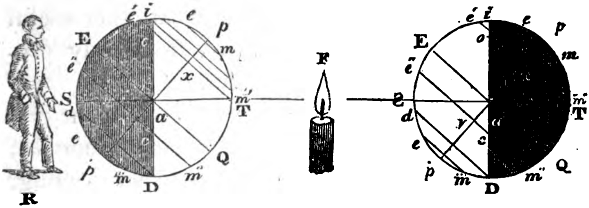
In this very un-miraculous manner. Looking first at the polestar, I found the *North;* then making a half *pirouette* on my heels, I looked exactly towards the *South,* or in the direction of the *meridian;* consequently as the Moon rose at that quarter of the horizon, (said he, pointing to a great distance), about eight o'clock, and will be on the meridian at about half-past twelve, she moves from that rising-place to the meridian in about $4\frac{1}{2}$ hours. But she is now about half-way between that rising-place and the meridian; therefore has been moving about half that time, or $2\frac{1}{4}$ hours. Hence I judged that it must be about a quarter past ten. I do not, however, recommend this as a very practicable or exact method of computing the hour: it is only to be resorted to in cases of necessity, and with any hopes of success only by those who are familiar with the celestial time-keepers. If it were the *Sun* indeed, a method somewhat similar would enable you to supply the place of a clock with considerable accuracy: I have known a peasant guess the time of day to a quarter of an hour, by merely taking a *rural observation* of the Sun's altitude.

The *altitude* of a celestial body is, I suppose, its distance from the horizon, said Eugenia.

Yes; reckoned on a great circle, called a *Vertical Circle*, which passes through the zenith and the body.

And what is *Azimuth?* inquired the Colonel.

The arch of the horizon, intercepted between the meridian of the place, and a vertical circle passing through the body whose azimuth you require.



EVENING ELEVENTH.

THERE was nothing which Franklyn more detested than a set conversation, especially if it were to be scientifical, and he the Grand Illuminator. In order to avoid the appearance of such formality, he always contrived to introduce an observation, or propose a question, which should naturally wind to the subject he had in view; and with the same preference of devious to straightforward instruction (which he grounded on the superior fertilization produced by sinuous rivers to that of regular canals), he frequently (as we have seen) chose to wind *from* the main subject into other channels, and return to it again, after these agreeable, and perhaps not less profitable, excursions. He was full of theories, too; and one of them (which we think pretty sound) was, that *entertainment is a part of utility.* He would argue that the distinction generally put between the useful and the entertaining was false oftener than it was true; for that, if the end of utility be human *happiness* (and what other useful end in utility?), entertainment, frequently producing happiness, must be useful.

But why do you speak of "entertainment *frequently* producing happiness?" demanded Eugenia; (for our Theorist, it would seem, this very evening, had, after the manner of all such speculators, gotten astride of his hobby above mentioned, and was now ambling delightedly upon it by her side through the orchard). Can we ever be entertained without being pleased, or, in other words, made happy,—at least for the moment?

To be sure not! replied he. But, although entertainment is, and must always be, happiness "for the moment," it may sometimes be but momentary happiness indeed, and afterwards continued misery. So that upon the whole entertainment may *not*, in all cases, produce happiness. Thus, for example: if a mechanic go to the play every night for entertainment, he spends both his money and time, becomes disqualified for, and disgusted with, business, and so, in the long run, his entertainment renders him miserable. If again, to bring the matter home to our own bosoms, we should read only poems and plays, and novels, and romances, that might be entertainment indeed, but such as would, most probably, at length render us morbidly sensitive, discontented with realities, ambitious of what is beyond our reach, visionary, and subject to that wasting sickness of the mind—*ennui*, which seizes upon us during the intervals of entertainment.

Not to speak of such entertainment generally interfering with those pursuits by which competence is acquired, and without which there can be no happiness, said the Colonel who had overheard the discussion.

True! or, in women, by interfering with their domestic duties, from the right exercise of which are derived innumerable benefits to society, as from the neglect of which proceed innumerable evils. In this opinion I am sure Mrs. St. George will join me, said Franklyn addressing her.

You don't want an advocate, replied she; the justice of your cause is evident.

Montaigne I think it is, continued Franklyn, who says, "we are governed by our *nurses;*" and most certainly our conduct in life is mainly influenced by those principles which we imbibe from our mother's breast, and from her lips; which we gather at her knee, and by her side, in that earliest, and best or worst of all schools—the *nursery*. Alfred's mother, perhaps, made him Alfred *the Great*. It was she who inspired him with the love of study and reflection, by *entertaining* him with Saxon songs and poetry; nor is it probable her instructions were confined to this; for whence, if not from her, did he learn his great qualities? His father, a weak and worthless man, neglected while he indulged him, and could scarcely implant those seeds of excellence in his son's bosom which were not engendered in his own.

Maternal education has still more influence, however, upon the morality than the intellect of mankind, observed the Colonel.

Yes, replied Franklyn; and to the attention of English mothers in their domestic seminaries I am disposed to impute that high degree of moral excellence which the English character retains, in spite of wealth and commercial prosperity, which have ever been the destruction of national virtue. Tyre, Sidon, Athens, Carthage, Venice, became totally demoralized by a few years of luxury; while England, for so many centuries the most prosperous of nations, has also been the purest; and I have no doubt that her prosperity itself has been, in a great measure, owing to her moral excellence. See the effect of maternal education! As that incorruptible patriot, and pattern of private nobility, Andrew Marvel, says beautifully of an individual, so it may be said of our whole happy nation:

> "This 'tis to have been from the first
> In a *domestic Heaven* nursed!"

He adds, however, what would now be deemed unnecessary, although, perhaps, much less so than in his puritanical age—

> "Under the discipline *severe*
> Of Fairfax and the starry Vere."*

Who was the "starry Vere?" inquired Isabel.

Mother of the individual congratulated, replied Franklyn; and so called in allusion to the brightness, purity, and heavenliness of her character,—not with reference to her astronomical pursuits, as the Tuscan Philosopher is designated in Byron's noble verse—"The starry Galileo and his woes."

Now you must tell me who Galileo was, and what were his woes, said Isabel.

He was a Florentine astronomer, to whom several of the earliest and most important discoveries in the science are owing. His invention of the telescope, and the extraordinary use he made of that instrument, is adverted to by Milton (who visited him in the dungeon of the Inquisition), where he describes the shield of Satan:

> "The broad circumference
> Hung o'er his shoulders like the Moon, whose orb
> Through optic glass the Tuscan Artist views
> At evening from the top of Fesolé,
> Or in Valdarno, to descry new lands,
> Rivers or mountains, in her spotty globe."

Why was he imprisoned? said Isabel. What crime had he been guilty of?

Heresy.

Could any one, so familiar with the wonders of Heaven, be an infidel? exclaimed Eugenia. He must have become lunatic by his intercourse with the Moon!

You agree with Young, then, said Franklyn, who declares, with great apparent justice,—"the undevout Astronomer is mad!" Indeed, I do not think it possible, unless robbed of his senses by the elevation, that any one could ascend into the sphere of stars without being led up to the throne of God! But Galileo was only a heretic in science. He held that the Earth revolved on its axis; an opinion contrary to that which, as I have told you, the infallible Court of Rome had unwarily adopted for many years; and for this was he cast into prison.

How long do you think the day is, Reginald?

Twenty-four hours, you banterer!

I mean from sunrise to sunset.

Oh! sometimes more and sometimes less. The longest day, I know, is June 21st, and the shortest, December 21st.

Of which the former is about 16 hours 34 minutes, and the latter 7 hours 44 minutes,—almost 9 hours difference! Can you tell me what produces this great inequality?

The Sun being longer *up* in summer than in winter.

But why should he be so?—You don't know?—I'll tell you. The ivory globe we talked so much about yesterday: you remember that? Well! when I held it opposite the flame, with my finger and thumb at its uppermost and lowermost points, you recollect that one-half of it (next the flame) was illuminated, and that the circle of light and darkness passed through the points by which I held it.

Do you suppose Isabel between it and the flame, as you did last night?

No; I have nothing to say to Isabel at present ("Thank the stars!" muttered she, as he proceeded): I merely hold the globe at some distance from the flame, in the manner described. Can you now imagine the globe pierced through and through, from my finger to my thumb, and a straight rod of wire introduced, on which it may turn as on an axis?

Yes; and its ends, where your finger and thumb are, will be the *poles.*

Very good! and where will be its *equator?*

On its surface, half way between the poles.

Good again! Can you further imagine a large flat thin circular *plate of glass*, through an orifice in the centre of which the flame rises, and whose plane spreads on all sides of the blaze as far as the wire axis of the globe, so as just to reach the middle point of the wire between the poles?

Not unless it was able to cut through the hard ivory substance of the globe to its very heart.

We will save it that piece of troublesome cruelty, and suppose the globe to be already sliced through its equator into two hemispheres.

Oh! then, indeed, the plate of glass may spread through the slice, between the hemispheres, as far as the wire, and one hemisphere will rest *upon* the edge of the glass, while the other is pressed upward to it by your thumb.

The wire, then, stands upright to the glass at its edge; and the circle of light and darkness passing through the wire ends, or poles of the globe, likewise stands upright to the glass, with this circle presented to the flame.

Yes; and that half of the globe between its face and the flame is illuminated, while the other half of the globe at its back is in darkness.

Preliminaries being settled, we are now in a condition to proceed, said Franklyn. To an *emmet* on any part of the illuminated half of this globe it would be *light;* and to an emmet on the other half it would be *dark.* Placing yourself exactly opposite me on the other side of the flame and glass plate, let me carry the wire round the edge of this circular plate, still keeping it upright, and still keeping that half of the globe you first saw presented towards you. When the globe comes edging round to you in this manner, how much of its *now* illuminated half will you see?

None: for the half I first saw is now between me and the flame, so is in total darkness; while the *back* half is now turned from me and presented to the flame, so is entirely illuminated.

Consequently, added Franklyn, if the emmets have kept their places, they will have changed *circumstances;* it will now be dark to the first, and *light* to the second. But answer me to this: while the globe was edging round to you, suppose me to have kept turning it on its wire axis the whole time, so as to have performed, we will say, 50 revolutions in the course of the journey; would not those two stationary emmets have been each 50 times in light, and 50 times in darkness?

Yes; for the half-globe on which *each* stands would be presented 50 times to the flame, and turned 50 times from it, on that journey.

Excellent! In fact, then, each would have passed 50 *days*, and 50 *nights*. Now tell me what would render those days and nights all equal to each other?

If you turned the globe evenly,—that is, I mean, —*equally fast* all the time, replied the Boy, after some reflection.

Just so! for then the enlightened and unenlightened halves would be presented to the flame, and hidden from it, for exactly the same period. You see, likewise, that if each emmet had a brood scattered over its own half, near and far from the equator and poles, all the members of each family would have the same day and same night. Nor would any emmet of either family have a *shorter* day or night than another, by being *nearer* one of the poles; for if both these emmets, in their respective *latitudes*, were on the boundary of light and darkness, when they were just about to be turned towards the flame, they would be wheeled round to the other side of the globe, and pass the boundary of light and darkness there, at the very same moment.

If they stood still all the time!—I see that! added Reginald.

The pole itself, said Isabel,—if you will endure an observation,—though we may suppose it a *wee wee* circle, not the size of a pin's head, turns only once, while the great equator makes one revolution, and all the circles of latitude between them. This is very clear!

So that, if an adventurous emmet stood on the *very pole itself*, added Franklyn, it would only be once twirled about in a whole day and night together!

How comical! It would have its head in light, and its tail in darkness, at the same moment,—and each for half the time of a whole revolution!

Comical as it may be, observed Franklyn, it is a very good illustration of the possibility of a *human being* standing on a pole of the *Earth*, without becoming giddy by its revolution. For *our* day and night making 24 hours together, he would be just so long in being turned about by the Earth's rotation on its axis; and how little extra giddiness this would produce, any one of you may find by turning on your feet, in the same place, from the present hour until the same hour to-morrow evening, *once round.* Isabel might try, perhaps—

Isabel might try no such thing! replied she with indignation.—Isabel has something better to do than undertake such an employment!—A profitable expenditure of time, indeed!

Yes, truly!—and you with the *National Debt* to get rid of in the meanwhile!—How could I have been so unreasonable? But, Reginald! said he becoming serious: what if the wire axis, instead of being perpendicular to the glass plate, were *inclined* to it? That is, suppose, having set it perpendicular, in the first position of the globe, I pulled the uppermost end, or pole, a little downwards, *from* the flame, and the lowermost pole consequently upwards towards the flame; what effect would this have? [See ENGRAVING at the head of this EVENING.]

Why, half the globe would be illuminated as before, and half would be in darkness; but neither would be exactly the same half as at first.

Right! A little of the former, at the top, would be drawn with its pole *backwards* from the flame, and would therefore be in darkness; while a little of the latter, at the bottom, would be drawn with its pole *towards* the flame, and would therefore be illuminated. The circle of light and darkness, consequently, would not now pass through the poles, but the upper pole would lie *behind* it, *from* the flame, and the lower pole *before* it, *towards* the flame.

The poor little emmets which *were* on the illuminated half, near the upper pole, added Reginald, would now be in darkness!

True! but then the fortunate little fellows which *had been* on the dark half near the lower pole, would now come into light; so, if the numbers were equal, a balance would still be preserved. Look! suppose F the flame, and a F a' the flat of the glass plate; and suppose E p Q p' to represent the globe, with its wire axis $p\,p'$ inclined to a F a'. Then the half $i\,p'$ D, which is presented to the flame, will be illuminated, and the half $i\,p$ D, which is turned from the flame, will be in darkness: and i D will be the edge of the circle of light and darkness standing upright on the circle like a *hoop* from i to D. When $p\,p'$ was perpendicular to F a, then all the emmets, such as e, between i and p, were in light, but now they are in darkness; whilst all those, such as m''', between D and p', which are *now* in light, were *then* in darkness. But if the globe be turned once on its axis $p\,p'$, as before, will all the emmets on the illuminated half *i p'* D, enjoy as before exactly the same length of light?

I suppose so!

That is unlucky for your astronomical reputation. Let E and *e'* be two of the industrious fraternity, one E at the equator EQ, and the other *e'* between the equator and the circle of light and darkness *i* D. Now, if the globe be turned on its axis *p p'*, it is plain that the latter gentleman *e'* will sooner come to the edge of the circle *i* D at *o*, by the revolving of the globe, than the latter gentleman E will come to the edge of that circle at *a*: for, conceiving the globe to be turned a quarter round, so that the edge of the meridian *p* E *p'*, instead of being as now flat on the paper, shall stand upright to it, *hooping* from *p* to *p'*,—emmet E would be on a point of this hoop just over *a*, when emmet *e'* would be on a point of the hoop just over *x*; emmet E, therefore, is just about to be whirled into darkness, but emmet *e'* has been already whirled into it by passing the edge of the circle *i* D at *o*.

I see now! Emmet E is whirled round to Q in the same time that emmet *e'* is whirled round to *m'*; but the former is half that time in light, and half in darkness, while the latter is *less* than half that time in light, and more *than* half that time in darkness, because it is a shorter time in whirling from *e'* to *o* than from *o* to *m'*.

The same things happen at the *other* side of the globe, added Franklyn; so that, in a whole revolution of the globe, emmet E's day is longer than emmet *e'*'s.

Emmet E's day is equal to its night, since it whirls from E to the point over *a* in the same time that it whirls from this point to Q, remarked Eugenia; but emmet *e'*'s day is shorter than its night, since it whirls to *o* in a shorter time than from *o* to *m'*.

Well observed! And if emmet *e'* had been yet farther from the equator, that is, if it had had yet higher latitude, it would have yet sooner been whirled into darkness, and yet longer continued in it: so that its day would have been yet shorter than its night.

Yes; and if it had been so far from the equator as *i*, it would have had no day at all, except for a moment at that very point! Is not that well observed too? demanded Isabel.

Much better than you intended, though perhaps not half so well as you think! replied Mr. Downright. For that is a very essential particular to be remembered. You see that by pulling down the half axis *p a*, from its upright position *i a*, I raised the equatorial radius E *a*, just as much, from its first position along *a* F *a'*; consequently the arch *ip* is exactly equal to the arch ES; and consequently an emmet *begins* to have no day, when he is at *i*, exactly as far from *p*, the pole, as the equator's most elevated point E is above the plane F *a*. Do not forget this peculiarity.

All the emmets, as at *e*, between *i* and *p*, are in total darkness, remarked the Colonel: they have not even a moment's day, but their night lasts during their whole revolution from *e*, through *m*, to *e* again.

Precisely!—But what shall we say of emmet e'', on the *other* side of the equator?

Why, answered Eugenia, after some hesitation, his day is still longer even than emmet E's! For you see how far he has to whirl, before he comes to the circle of light and darkness, from e'' to *c*!

Take heed lest you confuse yourself, by this manner of expression, said Franklyn: it is not that he has to be whirled *so far*, but for *so long a time*. The arch e'' *c* on the globe may not be longer, nor indeed as long as half the arch from E to Q,—but emmet e'', whirling over the point *v*, just when emmet E whirls over *a*, has to whirl yet longer before *he* comes to the circle of light and darkness at *c*: and therefore *his* day is longer than the other's. Thus emmet m''', which might be so near the pole p', that the circle *e* m''', in which he was whirled round it, should not be the size of your ring,—his day has *no* night, but is as long as emmet E's day and night together.

An emmet whirling in the circle between e'' and p', so as just to touch D, has no night in its *merry-go-round* neither,—except just a little gloomy moment when it is passing through D.

There is another valuable observation! cried Isabel undaunted by the reception her last had met with.

There is no quelling thy indomitable spirit! exclaimed Franklyn. It *is* a good observation,—and I believe you *now* intended it to be so!—By the pole p' having been raised from its first position D, the equator, as I said before, was raised just as much from S to E; so that the arch p' D is exactly equal to the arch S E. Consequently, an emmet *begins* to have no night, when he is just as far from the pole p' as the equator's most elevated point E is above the plane F *a*. Remember this peculiarity also.

What are you drawing now? inquired Reginald.

Suppose the globe to have edged half round the glass plate, as before, replied Franklyn, only that the axis $p\,p'$ is now kept leaning exactly in the same slant all the time, instead of being upright as at first. Observe, too, that it is not only kept all the time exactly in the same slant, but in exactly the same direction with regard to you, standing at the other side of the glass plate, that is, say that you stand at R, looking towards the north pole of the heavens, the wire pole p is not to be turned *this* way towards your right hand, nor *that* way towards your left, but to be kept steadily pointing towards the north pole of the heavens likewise.

Why then, if that be the case, said Reginald, when the globe has edged round to me, its pole p'

will now point towards my feet, and its pole *p* towards the flame!

Exactly so! And the globe will be exactly in the same position at *a′* as at *a*, and exactly under the same circumstances, with this slight difference, —that the illuminated half then will be the dark half now, and the dark half then will be the illuminated half now.

Yes; for *i* E D, which was presented to the flame then, is turned from it now, and *i* Q D, which was turned from the flame, is now presented to it.

You see, therefore, that if the globe be turned once round on its axis *p p′*, emmet E will be half the time in darkness and half in light; while emmet *e′*, which before was a shorter time in light than in darkness, will now be a shorter time in darkness than in light; emmet *e″*, which before was a longer time in light than in darkness, will now be a longer time in darkness than in light; emmet *e*, which before was all its time in darkness, will now be all its time in light; and emmet *m‴*, which before was all its time in light, will be now all its time in darkness: so those which before had longer nights than days, will have now longer days than nights, and those which had longer days than nights, will now have longer nights than days.

I see!—because, on turning the globe, emmet *e′* gets beyond the circle of light and darkness at *o*, before he gets to the point of the *hoop* over *x*, that is, before he gets half-way to *m′*; so he must be a shorter time in darkness than in light. On the contrary, proceeded Reginald, emmet e'' gets beyond that circle at c, after he has got to the point over v; so that he is a longer time in darkness than in light. Emmet E is as long in whirling from E to the point over a', as in whirling from that point to Q. But emmet e is not whirled through any part of this darkness, nor emmet m''' through any part of this light.

As for an emmet so far from the equator, towards p, as i, it there *begins* to have no darkness at all, except for the moment it touches darkness at that point; and an emmet so far on the other side of the equator towards p', as D, it there *begins* to have no light, except for the moment it touches light at that point. This is exactly opposite to what happened when the globe was at a, continued Franklyn.

But what is the use of all this about glass plates, and ivory globes, and emmets? demanded Isabel.

Merely to illustrate the Earth's motion in her orbit, with human beings on her surface, replied Franklyn with great humility. Imagine the circular glass plate to be a circular plate of air, whose radius F a, is the distance of the Sun from the Earth; imagine the flame F augmented to the size of the Sun; and the ivory ball swoln out to the magnitude of the Earth, with its axis pointing to the north pole of the heavens, and turning once round on that axis in the space of 24 hours, E Q being its equator, and E, e, e', e'', i, &c. human beings on the Earth's surface; with all this, imagine that the Earth moves round the edge of the circular plate of air, as the ivory globe round that of the glass plate, and you will then have an idea of what I said.

But is the Earth's axis *really* inclined to the plane of the ecliptic? said Eugenia.

It really is; inclined at an angle of 66½ degrees. That is, the arch *p* T, (or *p'* S) is sixty-six and a half out of the 360 degrees, into which the circle TLSD may be supposed to be divided. Consequently, as *i* T is a quarter of the whole circle, or 90 of those degrees, the arch *p i* (or E S, which I have proved equal to *p i*) is 23½ degrees.

And has the Earth's axis always this slant to the plane of the ecliptic, while it edges round as you say? inquired Isabel.

Always. That is to say, independent of a very small variation, which is below your notice, though it has engaged that of our most profound astronomers. But it is only a correction [page 231]; and you are above such minutiæ.

Well! come! Mr. Sneer,—no more sarcasm.—Let us hear something more agreeable! said Isabel.

When the Earth is at *a*, viz. with its north pole turned *from* the Sun, it is *winter* with us who live on the *north* side of the equator, and *summer* with those who live on the *south* side of the equator. When the Earth is at *a'*, viz. with its north pole turned *to* the Sun, it is *summer* with us, and *winter* with those on the *south* side of the equator.

How does this happen? inquired the Colonel.

Summer is only a short name for *continued comparatively hot weather*, replied Franklyn; and winter for *continued comparatively cold weather*, at any given place. Now, the first is produced by the Sun continuing for many days a long time above the horizon, whereby much heat is shed upon that place, and at the same time continuing for many nights a short time below the horizon, whereby the heat shed in the day has little time to evaporate during the night. The second is produced by means exactly the reverse. Hence, when the Earth is at *a*, it must be winter to those who live north of the equator, inasmuch as their days are short and their nights long; while to those who live south of the equator, it must be summer, inasmuch as their days are long and their nights short. But when the Earth is at *a'*, the former will have summer weather, and the latter winter. Thus, *we*, who have north latitude, enjoy summer weather when our days are longest, our nights being, at the same time, shortest; and endure winter weather when our days are shortest, our nights being at the same time longest.

How is it, then, sceptically inquired Eugenia, that—although I confess we have summer on the 21st of June, our longest day—our hottest weather is in July and August, when the days are shorter?

A very pertinent question!—For this reason: on the 21st of June, the greatest quantity of heat is shed upon us during the day, and the least quantity evaporated during the night,—because at that epoch the day is longest and the night shortest. But even after that epoch there is a greater quantity of heat shed upon us during the day, than is evaporated during the night,—because still the day is longer than the night. So that the heat is continually augmented during the days, more than it is diminished during the nights; and consequently, the heat being, on the whole, augmented after the 21st of June, the summer becomes hotter than at that epoch. For similar reasons, the coldest weather is not at the epoch of the shortest day, December 21st, but considerably after it, about the middle of January, because the heat is diminished every succeeding night, more than it is increased every succeeding day.

How strange!—I always thought that summer was caused by the Earth being nearer the Sun, and winter by its being farther from the Sun! exclaimed Isabel.

Like many other hypotheses, rejoined Franklyn, yours, however ingeniously it may account for the phenomena, is unfortunate in being contrary to fact. The Earth is *nearest* to the Sun in *winter*, and *farthest* from him in *summer*.

Oh! how do you prove that?—I can't possibly believe—exclaimed Isabel.

Stay! said Franklyn putting a green leaf, which he had been twirling by the stalk, before her mouth—'stay, Rosebud! Mark how I'll convert you in a moment! Have you ever observed that the Sun appears larger in winter than in summer?

I cannot say I have; but it may be so!

Nay, it *is* so!—Astronomers have measured the apparent breadth of the disc at both epochs, and actually found this to be the case. Of course, then, we must be nearer the Sun in winter than in summer, or it would not appear to be larger. I cannot say, as Johnson used, that I have "reduced you to *whistle*"—but you are silent, and what stronger proof could a lady give of her being in the most helpless state of conviction?

How are *Spring* and *Autumn* produced? said Reginald with his usual abruptness.

Why, you must know, replied Franklyn, that in edging round from *a* to *a'*, that is from winter to summer, the Earth at length comes to the middle point of the *half*-orbit between *a* and *a'*. There her axis does not present either of its poles to the Sun, as at *a* or *a'*, but stands *sideways* to the Sun, leaning however towards the flat of the ecliptic. The axis standing thus sideways to the Sun, with half the globe exactly between it and the Sun, while the other half is turned from the Sun,—the former half must be illuminated, and the latter in darkness. Consequently, the circle of light and darkness will *now* pass through both poles.

Then, instead of one pole being utterly in darkness, and the other completely in light, observed

Mrs. St. George, they will *both* be on the verge of light and darkness, and so both have night and day at once.

Yes. But an inhabitant at some distance from either pole will be exactly half the time of the globe's diurnal revolution in light, and half in darkness. So that——

Just tell me what is the precise meaning of "diurnal," said Isabel.

It comes from the Latin word *dies*, a day, and signifies in popular language *daily;* but in astronomical, it is applied to the whole revolution of the globe, or a *day* and *night* together. So that, as I was saying, inasmuch as we, on the north of the equator, have, in this position of the earth, our days equal to our nights,—each being equal to half the time of a whole revolution,—it must be our *spring season*, as we have supposed the earth to set out in *our* winter-time, from *a* towards our summer-time at *a'*.

To those at the *South* side of the equator, then, added the Colonel, it will be *Autumn*, as the Earth has set out from *their* summer-time towards their winter-time.

Exactly! And when it has edged round through *a'* to a point of the *other* half-orbit, opposite to this, it will be in similar circumstances, save that to *us* the season will now be *Autumn*, and to those on the *south* of the equator it will be *Spring*. Now *equinox* means equal-night (from *equus* equal, and *nox* night); also *vernal* means adjectively *spring* (from *ver*, the Latin for *spring*): hence, when the Earth is at these two opposite points of its orbit, midway between *a* and *a'*, those epochs are called respectively those of the *Spring equinox* and the *Autumnal equinox*,—according as it is spring or autumn to the inhabitants. Thus *our* Spring equinox happens on the 20th of March, and our Autumnal equinox on the 23d of September, at both which epochs our days and nights are equal to each other.

Then, of course, remarked Eugenia, those who live as far *south* of the equator as we live *north* of it, have their *spring* equinox exactly when we have our *autumnal*, and their autumnal when we have our spring? As for those at the equator itself, who had their days and nights equal at *a* and *a'*, just as well as now, they have,—which have they, spring or autumn,—all the year round?

They may rather be said to have all their four seasons in one, replied Franklyn. Because, their days and nights being always of the same length, no variation of temperature can ensue from that cause. But I forgot to specify a second reason, besides the inequality of days and nights, why the heat at a given place is greater or lesser according to different seasons. When the solar rays fall *slantingly* on any place, they do not cause so much heat there as if they fell *directly downwards*; for they are spread over a great expanse when they fall obliquely, and therefore are but thinly scattered on every part of it; but when they fall perpendicularly, they only cover the space immediately under the Sun, and are thickly condensed upon it. Now, taking this source of greater and less heat into view, the inhabitants at the Equator may be said to have *two* summers and *two* winters. For, as the ecliptic crosses the equator at two opposite points on the heavens, when the Sun in his annual course enters these two points, he will be directly overhead to the inhabitants at the terrestrial equator; at these two epochs, therefore, his beams will fall perpendicularly, or, as it is called, *vertically* (from *vertex*, the Latin for *head* or *top*), upon them. But when he passes out of these points, either to the north or south of the equator as far as he can go, that is $23\frac{1}{2}$ degrees on each side of the equator, he will *not* be overhead of these equatorial inhabitants, therefore his beams will fall slantingly upon them. Hence, at the first two epochs the heat will be greatest, and at the last two it will be least, for those inhabitants: wherefore the first two may be called *summers*, and the last *winters*, though both are hotter than our dogdays.

Is the Sun ever over *our* heads? inquired Reginald.

Now such a foolish question, after all the pains I have taken with you! cried Franklyn. Did I not tell you this moment that the Sun can only go 23½ degrees north or south of the celestial equator,—and are not we 51½ degrees north of the terrestrial,—so how could he ever be over our heads? Imagine a circle on each side of the terrestrial equator, and 23½ degrees from it,—he never can be over the heads of any persons but those who are between these two parallel circles, including a zone or belt of 47 degrees, which is, from this circumstance of its great heat, called the *torrid zone*. Imagine two parallel *celestial* circles corresponding to these,—that is, each 23½ degrees from the celestial equator, on different sides: these are called *tropics*, from a Greek word *trepo*, to turn; because, when the Sun has approached either of them *from* the equator, he then, as it were, turns back *towards* the equator again,—as he cannot go beyond either. The corresponding terrestrial circles are also called tropics, though somewhat improperly. Do you recollect the names of the signs? (page 83) *Cancer* is one of the most northern, and *Capricorn* one of the most southern; hence the northern tropic is called the *tropic of Cancer*, and the southern is called the *tropic of Capricorn.*

Are not the places where the Sun reaches the tropics called *solstices?* inquired Eugenia.

Yes; from a Latin word, *solstitia*, compounded of two, *sol*, the Sun, and *steto* to stand, because at those places the sun appears for a short time neither to move forward nor backward, and therefore may be considered stationary with respect to the poles. Have I told you what *declination* means?

Yes. [Page 110.]

It is the Sun's distance from the equator; and as he gains this by gradually verging or *declining* away from it after he has passed one of the equinoctial points, it is called his *declination*. A celestial circle parallel to the equator, and passing through his place, is called a *parallel of declination*. Each tropic is, therefore, a parallel of declination; and the Sun's greatest north or south declination, that is, his greatest declination on the north or south side of the equator, cannot exceed 23½ degrees.—I may as well here tell you what *Right Ascension* is. Imagine a quadrant of a circle from the pole to the equator, passing through any celestial body; measure the arch of the equator between the *vernal* equinoctial point and the point where that quadrant meets the equator; the said arch, if measured according to the order of the signs, will be the *right ascension* of the body.

What is the use of this hard name? said Isabel.

You shall learn. When the Sun is at the tropic of Cancer, what is his right ascension? Is it not 90 degrees? He is then just half way from the vernal to the autumnal equinoctial point; therefore a quadrant from the pole, passing through the solstice where he is, and reaching the equator, will divide the half-equator between those equinoctial points into two equal arches of 90 degrees each. Consequently his right ascension is 90°.—Now tell me what his right ascension is when at the tropic of Capricorn?

90 and 90 are 180, and 90 more will be—270, computed Eugenia; his right ascension will be 270 degrees!

Good girl!—He is now distant from the vernal equinoctial point, the half-equator between the equinoctial points, and half of the other half too, —which is just 270 degrees in all. This little practice will serve to confirm the idea of what right ascension is, in your minds. Now as to its use! Imagine such a quadrant, as also a parallel of declination, to pass through the Sun, when in any point of the ecliptic: by specifying the distance of the former from the vernal equinoctial point, and that of the latter from the equator, *i. e.* by specifying the *right ascension* and *declination* of the Sun, do you not state his position in the heavens?

Then it is a method of stating the Sun's position, as regards the vernal equinox? said the Colonel.

Yes; and is extended to *all* the celestial bodies. For the term *declination* is applied to the distance of *all* such bodies from the equator, as well as that of the Sun: and therefore by specifying the declination and right ascension, we state the position of a celestial body,—referring it to the equator and vernal equinoctial point, both of which we consider as fixed. Sometimes, instead of declination, the *polar distance*, or distance of the body from the pole, is used: which serves equally well, in conjunction with the right ascension.

Do *we* not live in the *temperate zone?* said Isabel.

In *one* of the temperate zones, replied Franklyn, viz. the northern. Imagine a circle round each terrestrial pole, and 23½ degrees from it. Each of these polar circles will be,—how far from the nearest tropic, Eugenia?

I must calculate slowly, replied Eugenia. From the pole to the equator is 90 degrees, and as the polar circle is 23½ degrees from the pole, it must be—66½ degrees from the equator; but the nearest tropic is 23½ degrees on this side of the equator, and therefore the polar circle must be—43 degrees from the nearest tropic.

43 degrees then is the breadth of the zone between each polar circle and the nearest tropic; which zones, because they are neither very hot nor very cold, are denominated *temperate*,—North and South, according as they are on the north or south side of the equator.

The *frigid zones* then are the two spaces round the poles, within those two polar circles? observed Eugenia.

They are, replied Franklyn; and each is 47 degrees broad, extending 23½ degrees both ways.

"Frigid," I suppose, remarked Isabel, because they are very cold?

A most happy conjecture! But can you form any supposition *why* they are so cold?

Because the Sun is so far from them, replied our wise woman.

Not quite so far as you are from the right answer! In the figure I last drew, can you not perceive that the flame is *nearer* the pole p' when the globe is at a, and nearer the pole p when the globe is at a' than to many other parts of the globe? No! the right answer is as follows. In the first place, the Sun's rays fall very *obliquely* upon these regions, inasmuch as they are so far from the equator and tropical regions, upon which only he shines perpendicularly. In the second place, at the north terrestrial pole, 90 degrees from the equator, since the celestial pole would be just in your zenith [page 35], the celestial equator would exactly coincide with your horizon. Now, while the Sun was in that half of the ecliptic, south of the equator, he would of course be below your horizon; that is, he would be invisible for *half a year*. Do you not think this would be very uncomfortable? Would it not render the pole a very *frigid* place of habitation? When he was just about to cross towards your side of the equator, he would become visible, and appear to move round you for the whole day, on the very brink of your horizon. Indeed, he would *continue* visible both that day, and the following days for *half a year*, viz. while he was in that half of the ecliptic on your side of the equator. So that you might be said to have but *one* night and *one* day in the year; each six months long! To be sure, you would have a great deal of *twilight*, both before the Sun crossed to your side of the equator, and after he had crossed to the other; because, as he traced his diurnal circles below the equator *parallel to it*, he would be for a long time just so little below it as to cause twilight. [Page 227.] This would be some consolation!

For all that, said Isabel, *I* should not like to be a *Polander!*

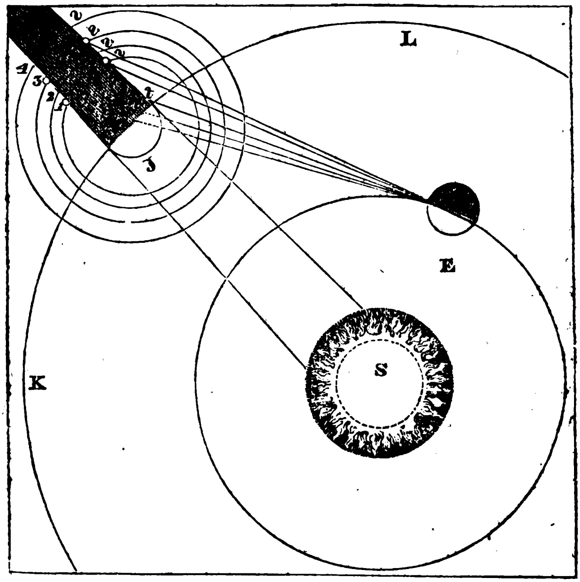
You would gain little by being an inhabitant of *Spitzbergen*, rejoined Franklyn, though it is between 10 and 15 degrees from the North Pole. Upon this place the Sun shines little less obliquely than on the pole: and although he is not, as there, invisible for half a year, he is invisible for a long time at the most northerly parts. To compensate for this, however, he remains visible nearly the other half year without cessation, when upon the North side of the Equator. At the lower parts of the island, where the pole is elevated about 75 degrees, and consequently one half the equator slants to 15 degrees above the horizon, while the other half verges to 15 degrees below it, when the Sun has his greatest south declination ($23\frac{1}{2}$ degrees) he will be farther from the equator than the horizon is, and therefore, revolving parallel to the former, will not get above the latter; in other terms, he will be invisible. And he will remain so, as long as his south declination is greater than 15 degrees. When this declination is exactly 15 degrees, his parallel of declination will, at its highest point, just touch the horizon, and he will then for a short time be visible. Afterwards the time of his diurnal visibility will increase in proportion as he gets nearer the equator, and when in that circle he will be visible for 12 hours. Henceforth, he will be longer above the horizon than below it; and upon gaining 15 degrees of *north* declination, his diurnal parallel, at its lowest point, will just touch the horizon, and he will be visible for the whole day. Still increasing his distance from the equator, his parallel of declination will continue to lie wholly above the horizon, and he will remain continually visible. So long as his north declination is more than 15 degrees, he will not descend below the horizon: and consequently, to the last-mentioned inhabitants of Spitzbergen, he will remain visible for several days together.

Yes, added Eugenia, whilst his declination increases from 15 degrees to $23\frac{1}{2}$ degrees, which it cannot exceed, and diminishes, as he returns from the Tropic towards the Equator, to 15 degrees again.

Well: now let me ask you one simple question, with which to conclude this Evening. At what latitude does the Sun begin to be visible for *the whole day?*

The Colonel, perceiving all his young Astronomers at fault, replied—At the latitude of $66\frac{1}{2}$ degrees.

Certainly, added Franklyn: because at this latitude, half the equator slants to $23\frac{1}{2}$ degrees above the horizon, and half to as many degrees below it. *Ergo*, when the Sun has $23\frac{1}{2}$ degrees of north declination, his diurnal parallel just touches, at its lowest point, the horizon, and he will be visible while performing that whole parallel. But, at a less latitude than $66\frac{1}{2}$ degrees, the pole will be elevated less than $66\frac{1}{2}$ degrees above the horizon, and consequently the lowest point of the equator will be more than $23\frac{1}{2}$ degrees below the horizon: wherefore the Sun, even at its greatest declination of $23\frac{1}{2}$ degrees, will have part of its diurnal parallel below the horizon. Thus in no part of Great Britain can the day be 24 hours long, unless we include twilight; for the Shetland Isles themselves, which are still more to the north than Caithness, the most northerly part of Scotland, have but 60 degrees latitude.



EVENING TWELFTH.

We must have neither badinage nor quotation, —indeed no trifling of any kind, this Evening, said Franklyn gravely; for it is the last I can spend with you at present, and there are a great many particulars to be added, in order to complete your knowledge of Elementary Astronomy.

Attention! said Isabel, mimicking the word of command.

Franklyn could not help smiling, but immediately correcting himself, proceeded to delineate a figure like that at the head of EVENING V.

This, said he, is intended to represent the Solar System; in other words, that collection of heavenly bodies whose movements have an immediate relative dependence on the Sun and each other.

You mean, added Colonel St. George, the Sun, Moon, and Planets.

I do; and many *other* heavenly bodies likewise. As first, the *Satellites* and *Rings* of those planets which have such companions; and secondly, *Comets*, both those which have been observed, and those which may revolve round *our* Sun as a centre. All these enter as legitimate members of the Solar System. But I do not reckon as members of this System those heavenly bodies, such as the fixed stars, whose connexion with the bodies just enumerated is not so immediate as to have any calculable effect on their movements.

Have the fixed stars, those inexpressibly remote bodies, inquired Eugenia, *any* effect whatever on our System?

Probably. Herschel discovered that our entire Solar System is moving as one body towards the constellation Hercules; which is, in all likelihood, an effect produced by certain of the fixed stars; but it is an effect so far from being calculable or expressible in quantities, that it is only perceptible by an Herschelian observer, and indeed is scarcely more than a very plausible conjecture. Definitions, however, are very dangerous things: who can tell but that what is *now* not calculable, may become so at one time or other? Hence in describing what we mean by the phrase, Solar System, it is best to enumerate those bodies which, and which only, it is held to comprise. If any new members should offer themselves, it will be easy to add their names to the catalogue. Let us now proceed to analyse this System a little more minutely.

You perceive, round the Sun in the middle of this figure, *seven* large circles, marked 2, 3, 4, 5, 10, 11, 12. These circles represent the *orbits* which the seven principal planets, *Mercury*, *Venus*, *Earth*, *Mars*, *Jupiter*, *Saturn*, and *Georgium Sidus*, perform round the *Sun*: but you are to observe that not one of the planetary orbits is an *exact* circle, though all are ovals *nearly* circular. In order to keep my sketch unconfused, I have not delineated the whole orbits of the four other planets, *Vesta*, *Juno*, *Ceres*, and *Pallas*, but merely small arches of those orbits, numbered respectively 6, 7, 8, and 9; inasmuch as these four orbits are so close together, that you could hardly see the intervals between them.

Well, and what is that *whip-lash* circle thrown over the Sun, with a little figure 1 crossing it? demanded Isabel.

That whip-lash circle, as you call it, replied Franklyn, is evidently no circle at all, but part of a very long oval, whose end farthest from the Sun reaches beyond the orbit of the Georgium Sidus. I intend it to represent the orbit of a comet.

How strange! exclaimed Isabel. I always thought that Comets were unintelligible things, that came one didn't know how, and went one didn't know where!

More than *one*, I suspect, rejoined Franklyn, thought and knew just as much upon the subject as you did. But the fact is, that Comets are little else than mere Planets which revolve round the Sun, in oval paths of enormous length, in most instances.

Now tell me, Franklyn, said Eugenia, why do you say, "*little else* than Planets," and "in most instances?"

Because if it were nothing but this extreme length and ovality of their orbits, in most instances, such would be enough to distinguish them from ordinary planets. You recollect, however, that they generally exhibit what are called *beards* or *tails*, which is a phenomenon that never accompanies a planet.

What then are those appendages which you have given those Planets on the four innermost circles? demanded Isabel.

Simply the *conical shadows* formed at the back of Mercury, Venus, Earth, and Mars, by the solar light being stopped at these bodies, as I showed you the other Evening. [169] But observe the tail of this comet; it is luminous and somewhat expanded, instead of dark and conical. Comets, however, do not always possess tails, properly so called; at least they only begin to exhibit them on their near approach to the Sun. When nearest the Sun, their tails are longest, and diminish as the Comets depart from his neighbourhood. Sometimes they are rendered nearly invisible by reason of the Earth's situation with respect to them; if, for example, it were in that part of its orbit (4) between the Sun and the Comet. In this relative situation, as the tail broadens from the Comet itself, we upon Earth should see it like a bright hazy atmosphere round the *nucleus*, or solid body of the Comet. From the resemblance of these appendages to splendid golden hair, it is that Comets obtained their name; the Greek term for hair being *komé*. So our most astronomical poet Butler says, (I *must* quote two verses, they are so apposite,) in allusion to that circumstance, combined with what was then believed the destructive nature of such ominous-looking bodies—

> "This *hairy meteor* did denounce
> The fall of sceptres and of crowns."

As to what the substance may be of which cometary tails are formed, there are almost as many opinions as there are astronomers. Dr. Hamilton of Dublin supposed them to consist of a material similar to the electric fluid, and that producing the Aurora

Borealis; whence it would result that they are *hollow*. This seems to be the most generally approved theory; and is corroborated by the fact that stars may be seen through the tails, without any sensible diminution of their lustre.

Of what substance is the Comet itself supposed to consist? inquired Mrs. St. George.

You mean the *nucleus* or *head* of the Comet. This has so faint and cloudy an appearance that it is often hard to be discerned with the best glasses; when visible it is of an opaque, solid character, but of no great magnitude, as compared to ordinary planets. Nevertheless, if one of these eccentric travellers of air were to come violently against the Earth, it would occasion no little shock to the nerves of many a person besides the "morbidly sensitive."

And is there any probability of such a collision, do you think? said Eugenia.

A remarkable Comet, seen in 1818, was found to revolve in an elliptic orbit, whose greatest diameter nearly equalled that of *Vesta;* the period of its revolution was about three years and a quarter, and therefore it must cross the plane or flat of the Earth's orbit more than 60 times in a century. Astronomers have calculated that there is a slight probability of the two orbits themselves crossing, and a slighter still of the Comet and Earth being, at that epoch, near enough to incommode each other.

"Incommode!" exclaimed Isabel; what a soft name you give it! And only remember the length of their tails!

Ay, indeed! returned Franklyn; some of them so long as to occupy more than half the whole arch of the Heavens, as did that of the Comet which appeared in 1681. Consider likewise the tremendous heat and velocity which these bodies attain when in the Sun's neighbourhood! Newton computed that the heat of one (if the substance were dry earth) must have been 2000 times greater than that of *red-hot iron*; and that it moved through nearly a million of miles in little more than an hour! You are to understand, besides, that even since the Christian era there have been 500 Comets observed, and but very few of these proved to be the same. Most of these will probably return into our system at different intervals; and many more, too, whose appearance, before that era, was not always remarked, or at least recorded. Notwithstanding all this, it has been computed by Laplace, and other celebrated Astronomers, that there are numberless chances against the dreadful event we speak of.

The end of the world must come at last, observed Colonel St. George; and perhaps it may as well come in this way as in any other!

It has been contended, with some appearance of reason, that the *Deluge* was occasioned by a slight brush from the aqueous tail of a Comet; and a repetition of this may be needed at no great distance of time to wash away sin from the world.

Instead of allowing such a prospect to convulse us with mean terrors, said Mrs. St. George, it should only warn us to stand in continual preparation for whatever casualties may happen in this state of uncertainty.

Why then, said Reginald to Franklyn, instead of there being but eleven planets, there are, in reality, five hundred and eleven, if not a great many more?

Probably so; if by planets we understand heavenly bodies which revolve in orbits of any kind round the Sun. There is, however, another distinction between Comets and ordinary Planets, *videlicet;* the orbits of the former are inclined at all angles to the ecliptic,—some being actually *perpendicular* to it,—while the orbits of the latter (with a single exception in favour of Pallas) are almost coincident with that of the Earth. Yet another distinction is, that in their courses about the Sun, not a few of the Comets move across the heavens from east to west, or *retrograde,* while the ordinary planets, whatever they may appear to do, always really move from west to east, or *direct.* Let me give you a little further information on this latter point, *videlicet:* the motion of the planets round the Sun—of the *ordinary* planets.

You perceive in the figure I have drawn, that the orbits, 2 and 3, of Mercury and Venus, are *within* the orbit, 4, of the Earth: for this reason

Mercury and Venus are called *inferior* planets. On the other hand, all the eight remaining planets are called *superior* planets, their orbits lying all *without* the orbit of the Earth. Now suppose a line drawn straight from the Earth where it is, near the figure 4, through the figure 3, on Venus's orbit, to meet the ecliptic, we will say at ♌ *Leo.* Suppose Venus to be at 3, and the Earth to remain fixed; it is evident that, while Venus moves through the upper part of her orbit from 3, to where her disc is sketched nearly opposite 3, the straight line aforesaid, always passing through her body, will move from Leo to about ♏ *Scorpio;* and that, as Venus is always seen by us in the direction of this line, she will appear to move according to the *order of the Signs,* Aries, Taurus, Gemini, Cancer, Leo, Virgo, &c. or *direct.* But Venus still proceeding, when she comes to a place on her own orbit nearest to 4, the said line will just touch or graze her orbit, and its end will reach just about to the tail of ♏; consequently that line cannot, when she proceeds yet further *in her orbit,* move any nearer to ♐ *Sagittarius;* that is, she herself cannot appear to move any further *direct.* On the contrary, as she proceeds from the place opposite 4 through the under part of her orbit, towards 3 again, the said line from Earth passing through her body, will move *back* from the tail of ♏ through Libra towards ♌ again; and Venus, being seen in the direction of this line, will now appear to move *contrary* to the order of the signs, that is, *retrograde*. Suppose the said line to touch or graze her orbit a little below Mercury; its end would reach to about the division between ♌ and ♋ Cancer; here the line must stop in its retrograde motion, as it cannot move any farther towards ♊ *Gemini*; and consequently, it is only between these two positions, in which the line touches or grazes the orbit of Venus, that she can appear to move retrograde while in the *under* part of her orbit. While in the *upper*, she will appear to move direct, between these same positions; for proceeding from the latter towards 3, the line aforesaid will move its end from the division between Cancer and Leo towards Leo, whence it first set out; that is, will move according to the order of the signs, or *direct*. Is not all this very plain?

Very, said Eugenia. So that, in fact, when the planet begins to retrograde, she is at her greatest possible width from the Sun at one side, and when she ceases to retrograde, at her greatest possible width from the Sun at the other side?

Admirably well observed, replied Franklyn, though not altogether accurately. For you must remember that our reasoning has proceeded on the hypothesis of the Earth being *fixed*: let us see what effect on the planet's movement results from the Earth's movement in the meanwhile. Apropos to your observation, however: when the planet is in such point of its orbit with respect to the Earth that the straight line joining these two bodies is widest apart from the Sun; then the planet is said to be at its greatest *elongation* from the Sun, or, in other words, the angular distance or *width* between the centres of the Sun and planet is greatest, and the arch between them on the heavens is *longest*. Hence you see that there are *two* points of greatest elongation; one at each side of the Sun. And for Venus, each of these arches of greatest elongation is 47 degrees, little more than quarter of the whole arch of the visible heavens. When therefore she is elongated about this distance to the east of the Sun, she would begin her arch of retrogradation, according to Eugenia. But this is not the fact, and could not be so, as you shall perceive. Suppose a line drawn from the Earth, and passing through Venus, considered at rest in any part of her orbit, say at 3, to meet the zodiac, say at ♌: as the Earth moves from 4, it carries its own end of this line with it, say to the orbit of the comet, and therefore the zodiac end will move from ♌ to about the division between ♌ and ♍; hence the movement of the Earth is *always* calculated to give the planet an apparent *direct* motion. If therefore she set out from her greatest elongation, somewhat below 3, she would appear, both by her own and the Earth's motion, to move *direct*, at least till she came to her other point of elongation. Here I have shown, that by her own motion she would appear to *retrograde;* as also that by the Earth's she would appear to move *direct*. Consequently, if these opposite tendencies were *equal*, they would exactly countervail each other, and she would appear to move *neither* direct nor retrograde; in other words, she would appear *stationary* in the heavens. And so in fact *she does;* that is to say, not exactly at her greatest elongation, for as there, however fast she moves in her orbit, she changes her distance from the sun but little, the aforesaid tendencies are *not* equal, but the retrograde tendency derived from her own motion is exceeded by the direct tendency derived from the Earth's, and therefore she still appears to move direct. When she approaches nearer to *inferior conjunction*, that is, to a position between the Sun and Earth, then indeed the retrograde tendency derived from her own motion becomes equal to the direct tendency derived from the Earth's motion, because she changes her distance from the Sun rapidly; and at this juncture she appears *stationary* in the heavens.

I do not understand, said Isabel, what you mean by saying, that at her greatest elongation the planet "changes her distance from the Sun but little," and nearer conjunction changes it rapidly.

By her distance, I mean her *angular* distance. Suppose her at her greatest elongation nearest to 4, and to move thence through a certain arch of her orbit; you see by the figure that this motion of hers will carry the grazing line but a very little backwards from the tail of ♏, inasmuch as she rather moves *towards* the Earth than *across* it. Now, suppose her in the point of inferior conjunction, and to move thence through an arch of her orbit equal to the former, this motion of hers will carry the said line rapidly backwards, inasmuch as she now moves *across* the Earth, as it were, in her own orbit. Conceive an arch on the heavens, something more than a tenth part of the whole arch of the hemisphere above us, and with its middle point *exactly* in the point of inferior conjunction: through this arch of about 16 degrees long, Venus appears to move retrograde.

That is to say, added the Colonel, if we took an arch of 8 degrees long on each side of the division between ♍ and ♎, and supposed the Earth where it is in the figure (exactly opposite that division), Venus would appear to move from the beginning of that arch in ♎ backward to the end of that arch in ♍.

Nearly so, replied Franklyn; on the hypothesis that her orbit was flat with the plane of the ecliptic, which it is not, but elevated about 4 degrees above it.

Recollect, continued he, that a planet is said to be in *superior conjunction*, when in such part of its orbit that the Sun is between it and the Earth.

Are they ever in *Opposition*, asked Eugenia, as described in the case of the Moon? (Page 238.)

Yes; the *superior* planets, answered Franklyn, when the Earth is between them and the Sun. Well!

every thing we have seen with regard to Venus is true of the other inferior planet Mercury, with the exception that neither his arch of greatest elongation, nor of retrogradation, is so great. Now let us consider the superior planets. Take Mars in the orbit 5, and suppose him where that figure is. Draw a straight line from the Earth (which we will suppose at rest) through 5, till it reaches to about the division between ♌ and ♍. It is plain, that as Mars moves in his orbit from 5 to where I have sketched his disc, the said line will be carried forward into ♎; that is, Mars will appear to move *direct*. And this would be the case throughout his whole orbit, if the Earth remained at rest. We must now calculate the effect of *its* motion, by supposing *him* at rest. It is plain that if he was fixed at 5, while the Earth was where I have sketched it, upon its moving in its orbit from 4, say to the comet's orbit, the aforesaid line would have its end in the zodiac carried forward from the division between ♌ and ♍ somewhat towards ♎; that is, Mars would, by the effect of this motion in the Earth, appear to move *direct*. But suppose that Mars, instead of being at 5, were in that part of his orbit just above that little Moon I have sketched near the Earth. In this position of the two bodies, the line connecting them and prolonged to the zodiac would reach to about the division between ♈ *Aries* and ♉ *Taurus;* and now, if the Earth moved towards the comet's orbit, while

Mars was fixed, the zodiac end of the aforesaid line would be carried backwards to ♓ *Pisces;* so that by this means the planet would now appear to move *retrograde.* Hence we see that while Mars is in the upper part of his orbit, he appears to move direct, both on account of his own motion and that of the Earth; but when in the lower part of his orbit, nearly opposite the sun, that he appears to move retrograde.

His retrograde movement, occasioned by the Earth, must then exceed the direct movement which he himself always has in every part of his orbit? interrogatively added Eugenia.

I should have recollected to say so, replied Franklyn; it does, because the Earth's velocity in her orbit is greater than the velocity of Mars in his, and therefore her velocity carries the zodiac end of the line more backwards than his carries it forward. His whole arch of retrogradation is very little greater than that of Venus; and his retrogradation happens when he is near his *opposition*, this taking place when the Earth is between him and the Sun.

Does he ever become *stationary?* inquired Isabel.

Of course: when the retrograde effect produced in the lower part of his orbit by the Earth's motion is exactly equal to the direct effect resulting from his own motion. Draw a straight line through the Earth, just touching or grazing her orbit, and lengthened both ways to meet his. So long as he is on the same side of this with the Sun, he appears to move *direct*, both by his own and the Earth's motion; but so long as he is on the opposite side of this from the Sun, though by his own motion he would still appear to move direct, by the Earth's motion he would appear to move retrograde. His own direct tendency is, however, not counteracted by the retrograde tendency for some time after he has got below this line, and for some time before he gets above it at the other end; so that he appears stationary, first, for a little time before he begins his arch of retrogradation; and, secondly, for a little time after he has completed it. When he is at either extremity of the grazing line in his own orbit, he is said to be in *quadrature*.

"Quadrature!" had we not that word before? said Isabel.

Yes (page 245), with respect to the Moon; and it expressed the time when about half her disc was illuminated. It has not the same meaning with respect to the planets; for when at the extremities of the grazing line, much more than half the disc of Mars would be visible, and almost the whole disc of the other superior planets. All these planets are, therefore, either fully illuminated when nearly in a line with the Sun and Earth, or when elsewhere very *gibbous;* in other words, their sides, not completely illuminated, appear very convex or protuberant. In their quadratures, however, they are all least gibbous.

Can you explain *why* they do not go through like phases as the Moon? said Mrs. St. George.

Because of their great distance from the Earth and Sun, replied Franklyn; whence all these planets are seen from both Earth and Sun in nearly the same direction; and therefore nearly the whole side of each planet, illuminated by the Sun, is presented towards the Earth. Such is not the case with those called *Inferior* planets; they exhibit all the different phases of little moons. At superior conjunction, both Sun and Earth looking full upon them, they exhibit full discs; at the points of greatest elongation, they are viewed sidewise by the Earth, in a line perpendicular to that in which they are viewed by the Sun, and therefore but half their illuminated hemispheres are exhibited to us; at inferior conjunction, being between the Earth and Sun, their illuminated hemispheres are turned wholly from us, and they disappear. Observe, however, that although these two planets are full at superior conjunction, and then only,—they are not then brightest, because of their great distance, and their being drowned in the beams of the Sun. Venus is brightest when a little nearer the Sun than her two points of greatest elongation: in these positions she occasions a strong shadow in the absence of the Sun, and may be seen in full daylight with the naked eye for a considerable time, both before and after she is in these positions.

Is this the reason of her being called the "evening star?" asked Eugenia.

Her brightness? Yes; answered Franklyn. When between superior and inferior conjunction, as at the place where I have sketched her, she appears to us on Earth in a more forward sign, ♏, than the Sun who appears between ♏ and ♎; consequently, as the signs run in order from west to east, she must appear more to the eastward than he; and therefore will be seen in the west after he has descended; whence she is called the western or evening star. But she is not *always* an evening star; for when too near inferior conjunction she will not be visible at all. Sometimes, indeed, she is so far from being an evening star, that she is a *morning* one.

When can that be? said Isabel incredulously.

Why,—when she is moving from inferior conjunction towards superior! returned Franklyn. Suppose her at 3, will she not now appear between ♌ and ♍, while the Sun appears between ♍ and ♎? Consequently, will not the Sun appear more forward among the signs than she; that is, more easterly? When, therefore, he is about to *rise* in the east, she, being west of him, will have risen already, and will, on that account, be a *morning* star. But when near inferior conjunction, not being distinctly visible, she is neither an evening nor a morning star; and Jupiter, who is next to her in brilliancy, takes her place sometimes in one of these characters.

At the end of our discussion concerning the primary planets, I have to remark, that these direct, retrograde, and stationary appearances, being all explicable to the smallest minutiæ on the *Copernican* system; namely, that system which places the Sun in the centre, with these eleven planets revolving about him; very much strengthens our reliance on the truth of that system. Here is another of those useful little Tablets which express in one view the principal elements of the Solar System. This expresses the respective distances of the eleven primary planets from the Sun; as also the respective periods of time in which they revolve once about the Sun, in their several orbits, technically called their *periodic times*.

Distant from Sun.	Millions of Miles.	Periodic Time.
Mercury	37,000,000	87 days.
Venus	68,000,000	224 d.
Earth	96,000,000	365 d.*
Mars	144,000,000	686 d.
Vesta	225,000,000	1335 d.
Juno	252,000,000	1582 d.
Ceres	263,000,000	1681 d.
Pallas	265,000,000	1681 d.
Jupiter	490,000,000	12 years.
Saturn	900,000,000	29½ y.
Georgium Sidus . .	1,800,000,000	83 y.

* The length of our Year is 365 days, 5 hours, 48 minutes, 48 seconds, almost exactly.

We shall now advert to the *Secondary* planets, or *Satellites*, of which the Moon is one; this having been already considered, will serve to illustrate the properties of the others.

You see, continued Franklyn, that in our sketch of the Solar System, we have drawn *four* little circles (though not very distinctly, indeed), around Jupiter, as a centre: these are to represent the four orbits of four satellites which revolve about him, as their primary, as the Moon revolves about the Earth. In like manner Saturn has *seven* circles around him, and the Georgium Sidus *six* around him, to represent the orbits of their respective satellites, Saturn having seven, and the Georgium Sidus six of these Moons, to attend him; which must be a glorious as well as useful retinue for each primary. You may guess that these three planets, being at such immense distances from the Sun, must require a good deal of moonlight, in which commodity they seem well provided, by means of their numerous satellites; though, of course, I do not think of limiting the uses of these moons, no more than of our own, to this single one.

Is not Mars more distant from the Sun than the Earth is? smartly demanded Isabel.

I cannot deny it, answered Franklyn, though I see to what straits the concession will reduce me.

Why, then, continued his Interrogator smiling; why then has not Mars a moon to supply him with light, as well as the Earth?

With the utmost humility, replied our Astronomer, I confess my ignorance!

Isabel could hardly suppress her joy at having, for *once*, perplexed the Infallible.

It is some consolation, however, added he, that *Newton* was not a whit wiser than I am upon this subject. I see you would rather find me ignorant in less respectable company; but the fact is so! Perhaps you will allow me, since I can afford you no certain knowledge on the subject of your interrogation, to furnish you with a conjecture, which may possibly satisfy your inquisitive spirit. Mars, you know, is distinguished from all the other planets by his sanguine or fiery hue: this will often serve to detect him. May we not, therefore, suppose that his material, or texture, is of a more *illuminable* quality than that of the other planets; that it more readily receives and reflects the solar rays; and that, by this means, his deficiency in moons and moonlight may be compensated? But, however this may be, I have enumerated all the known satellites of our Solar System, and I cannot create any more either for Mars's convenience or my own.

Jupiter, then, continued Franklyn, has four satellites, whose distances from his centre are respectively 6, 9, 14, and 26 times his radius; and which revolve about him in periodic times of about 1 day and three-quarters, 3 days and a half, a week, and 16 days and a half, respectively. I have here sketched these five bodies on an enlarged scale, with the Sun, S, in the centre of Jupiter's orbit, KL. [See the ENGRAVING at the head of this Chapter]. J is Jupiter, with his shadow extending in a direction opposite to the Sun S; 1, 2, 3, 4, are the satellites on their four orbits respectively. E is the Earth in her orbit. Now when any one of these satellites comes between Jupiter and the Sun, they cast a shadow on the disc of their primary: this proves two very material points, viz. that both he and they are *opaque* bodies, illuminated by the Sun, and neither transparent nor self-shining. Again; each of these satellites, when passing behind Jupiter, has been under certain circumstances rendered invisible, or, in common speech, has been *eclipsed*. I say, "under certain circumstances," because on account of their orbits being inclined to Jupiter's, they are sometimes behind him without entering his shadow, just as our Moon is frequently behind the Earth as respects the Sun, and yet is so far from being eclipsed that she is *full*.

Are any of Jupiter's satellites as large as our Moon? asked the Colonel.

Yes; one at least, replied Franklyn; but they are so very minute, at their great distance from us, that it is hard to compute their magnitude exactly. According to Laplace, the innermost satellite, as seen from Jupiter, *appears* just about the size of our Moon; and as it is about the same distance from him (namely, six times his radius of 44,000 miles), we may from this conjecture that it must be *really* about the same size. Let us proceed with the eclipses. Supposing the Earth at E, and the inner satellite just entering the shadow at S, its immersion, or eclipse, will be observable; but if it were at 1, its emersion would not be visible, inasmuch as the line of view from E to 1 would be intercepted by Jupiter's opaque body. The same things take place with respect to the second satellite, whose orbit is marked S 2. But with respect to the third satellite, whose orbit is marked S 3, *both* immersion and emersion are frequently visible from the Earth, inasmuch as a line drawn from the Earth to graze Jupiter's surface at *t*, frequently, though not always, passes between Jupiter and the third satellite, so that the latter is to be seen above it, emerging from the shadow. Similarly with respect to the fourth satellite. I must now explain to you an illustrious fact, which these eclipses of Jupiter's satellites first discovered to Roemer, a celebrated Danish astronomer. The fact itself is, that *light is not transmitted instantaneously*, but with a velocity of about *two hundred thousand miles* in a *second.*

I can hardly form any idea of such velocity, said Eugenia.

This, perhaps, will assist your imagination, returned Franklyn: You know that the Moon is about 240,000 miles distant; light would travel from her to Earth in about one second and a quarter of a second.

Astonishing! but how was this discovered by the eclipses of Jupiter's satellites?

Thus: Suppose, in our sketch of the Solar System, that the Earth was nearly between Jupiter and the Sun, we will say, about where the comet's orbit crosses her own; and suppose an eclipse of a satellite to take place at this epoch. Now, if light were transmitted not progressively, but instantaneously, this eclipse would be observed no earlier at the Earth in her present position, han if she were at the opposite point of her orbit, inasmuch as it would travel along the whole diameter of her orbit in *no time*. Eclipses, however, were observed to take place 16 minutes earlier when the Earth was where we have placed her, than would have happened if she had been at the opposite point of herorbit, about half way between 4 and Venus's shadow. Consequently, light, so far from being transmitted instantaneously, must take 16 minutes in passing from one end of the diameter of the Earth's orbit to the other. Now the length of this diameter we have seen to be about 192 millions of miles; which, divided by 16, gives 12 millions of miles for the distance travelled by light in 1 minute; and this, divided by 60, gives 200,000 miles for the distancc travelled by light in 1. The computations to establish this truth accurately are too mathematical and refined for us; and

and you will, I am sure, excuse me from going through them.

This is, indeed, an extraordinary use to which these insignificant objects, as I must take leave to call them, observed the Colonel, have been made subservient.

If the significancy of things, replied Franklyn, is to be measured by their effects upon the great system of things, few will be found more important than Jupiter's satellites. In the first place, they serve mainly to establish the Copernican or true theory of the world. Galileo discovered them in 1610; and taking them at first for fixed stars, was much disturbed the next night on observing Jupiter to the eastward of them, for this indicated that his motion was direct, whereas, by the Copernican theory, it ought to have been retrograde. Soon afterwards, however, he detected, that instead of Jupiter having moved eastward, his apparent change of place was occasioned by these four bodies which had moved westward: this confirmed him in the theory he had previously thought endangered. Eclipses of the Satellites, as we have shown, determined the progressive motion of light; and hence Dr. Bradley drew a conclusive proof for the motion of the Earth in its annual orbit.

How miraculously these circumstances, remote as they seem to us, are connected! exclaimed the Colonel.

Ingeniously, you mean, observed Franklyn;

there is nothing miraculous about the connexion. Bradley observed a yearly motion in the fixed stars, called *aberration*, which he explained by the progressive nature of light combined with the annual motion of the Earth in her orbit taken for granted. Hence, this annual motion of the Earth must be granted, in order to explain that annual motion of the stars.

O then, I see, observed Isabel, the fixed stars are *not* fixed; they are subject to what you so learnedly term "aberration!"

This may be a learned term to you, perhaps, Miss Isabel, replied Franklyn; but it is familiar as a household word to those who know even very little of Astronomy. It is used to express small circles, which stars near the pole of the ecliptic *seem* to describe about their true places; for the motion is *not* in the stars themselves, but, as I told you, results from the combined motions of light and the Earth; it is also used to express those small ovals, or arches, into which the circles of aberration become apparently converted when the stars are situate between the pole and plane of the ecliptic, or in the ecliptic itself. Planets and Comets are likewise subject to aberration.

Eclipses of Jupiter's satellites, continued Franklyn, are likewise serviceable in determining the *longitude* of places on the Earth's surface.

Is not this considered a very difficult problem, said Eugenia,—to find the longitude?

Very, when required with great exactness, replied Franklyn; but the principle of it is not difficult to be understood. In the following explanation, one or two other subjects, with which it is necessary you should have some acquaintance, will, I hope, be elucidated. You recollect that if the transit of a star over the meridian of a place be observed, as likewise any number of its successive transits over the same meridian, the interval of time elapsed between every two successive transits will be found always the same [page 62]. This interval is denominated a *Sidereal day*, from *sidus*, the Latin for a star. Also, as the stars revolve, or rather the earth rolls on its axis, at an equable pace, if this sidereal day were divided into 24 hours, the successive apparent arches travelled by a star in successive hours, will be all equal to one another; and therefore each would be the 24th part of 360 degrees, that is 15 degrees. Hence, if 24 meridians divided the equator into 24 arches of 15 degrees each, these 24 meridians might be called *Hour Circles*. So that, in fact, the *Right Ascension* of a star [page 289] would be as easily reckoned or registered in *sidereal time*, as in degrees of the equator. Thus, suppose a star have 90 degrees right ascension, (that is, suppose the meridian passing through it be 90 degrees from the first point of Aries), as six times 15 make 90, there must be six of the above *hour-arches* in the whole right ascension of the star, whence it may be said that the star has six *hours* of right ascension. And so for all other examples. But it is evident, continued Franklyn, that if the Sun and a star were at the same meridian together, when the star came next on the meridian, we should not find the Sun there too. For in the interval of this sidereal day, the Sun has moved eastward, while the star has remained fixed, so that the meridian having reached the star in 24 sidereal hours, will have to move eastward to reach the Sun; and so the interval elapsed between two successive transits of the Sun over the meridian will be greater than 24 sidereal hours. This interval is a *common solar day*.

This also consists of 24 hours, observed the Colonel.

Why, yes, admitted Franklyn, so it is usually imagined.

"Usually," rejoined the Colonel laughing; universally, I believe. Who can think otherwise?

Every one, drily replied Franklyn, who has compared the length of a solar day with that of a sidereal. While the latter is perpetually invariable, the former is never so. A solar day is longer than a sidereal, sometimes by one quantity, sometimes by another. Whence, to say that it consists of 24 hours, shown by a well regulated time-keeper, is totally erroneous.

Well, this is something new! exclaimed Isabel. Then, in fact, the Sun *goes wrong*; and the phrase "my watch goes as regular as the Sun," is founded upon a falsehood.

It is; if it mean that by going as regular as the Sun, it goes therefore with perfect regularity. For a perfectly regular watch, or *chronometer* of any kind, so far from going exactly with the Sun, is almost never exactly with it.

What is the meaning or the reason of this? inquired Mrs. St. George.

There are two reasons, answered Franklyn. If the Sun moved in the equator, and equably in that circle, it would change its right ascension equably; then indeed the length of a solar day would be invariable, and a regular time-piece, adapted to show apparent *solar* time, would always keep time with the Sun. But in the first place, the Sun (or rather the Earth) does *not* move equably in its orbit; and in the second, even if it did, that orbit (the ecliptic) being *oblique* to the equator, would cause the Sun to change its right ascension unequably; for both these reasons, the Sun moves in right ascension irregularly, and therefore does not *go* regularly, and therefore cannot go with a time-keeper which does go regularly.

Then if our watches and clocks do not go with the Sun, they do not show *apparent solar time*, as you called it, remarked Eugenia: now what time do they show?

Perfectly regular watches and clocks generally show *mean solar time*, replied Franklyn. By "mean," you are here to understand *medium.* Suppose an imaginary Sun to set out with the real Sun from a certain point in the equator, and moving equably to make one complete revolution in the *equator*, while the real Sun moving unequably, completes its revolution in the *ecliptic;* the imaginary Sun shows *mean solar time*, while the real shows *apparent solar time.*

Now that we have gotten precise ideas of time, let us recur to our problem of finding the longitude. Conceive a great circle of the Earth passing through Greenwich Observatory, as the principal meridian from which the longitudes of all places on the Earth's surface are to be reckoned; and that a spectator at Greenwich observes an eclipse of one of Jupiter's satellites to take place, when his *celestial* meridian passes through a given star. Now it is evident that to a spectator on a different meridian, this eclipse will take place either before or after *his* celestial meridian passes through that given star. If, for example, his meridian be 15 degrees *west* of the Greenwich meridian, his celestial meridian (or *hour circle*) will also be 15 degrees west of that of Greenwich, and therefore will not pass through the given star for an hour of sidereal time. Consequently, when the spectators compare notes as to the time when each observed the eclipse, a difference of exactly one sidereal hour will appear between them. Reversely, if on comparing such notes, a difference of exactly one sidereal hour appeared, would not this indicate that the two meridians had been 15 degrees of the equator asunder?

Evidently, replied the Colonel; and therefore, that the two spectators have 15 degrees of right ascension between them.

Longitude, you mean, rejoined Franklyn; the term right ascension is applied to celestial bodies only. Wherefore, considering longitude to begin from the meridian of Greenwich, the second-mentioned spectator would find himself to have had 15 degrees *west* longitude at the place supposed, whose longitude is therefore determined. Recollect, however, that longitudes are by many nations reckoned from the meridian of Paris, and other capitals. In old times, when the Canary Isles were the most westerly lands known, longitudes were generally computed from the meridian of Ferro. Recollect also that longitude is sometimes reckoned *eastward* for the whole 360 degrees all round the globe: thus a place having 15 degrees *west* longitude, is otherwise said to have 345 degrees *east* longitude.

But how does the process you have described, said Eugenia, enable a person to tell in what longitude he is, when he cannot immediately compare notes with a person at Greenwich?

It will only enable him to do so, replied Franklyn, if he has access to a book in which are registered the times when such eclipses happen at Greenwich. These times are computable long before they happen. And though, in order to simplification, I have explained the process with reference to *sidereal* time, comparisons between observed *mean solar*, or *apparent solar* times, would do as well; the three kinds of time being all easily reducible, one into another.

Whence then, demanded the Colonel, arises the difficulty of finding the longitude *at sea*, for which *Hadley's Sextant* is deemed so requisite?

Because of the unsteadiness of the ship, which renders it hard to take an observation with accuracy. The principle of Hadley's Sextant I could not well explain without the use of *geometry;* but it is chiefly applied to finding the longitude by determining exactly the Moon's place with regard to the fixed stars. This method is hence called the *lunar method*. Having determined the apparent position of the Moon, it is to be corrected for *refraction* [page 231], and then reduced to the position in which it would be seen from the *centre* of the Earth instead of the surface. You can easily imagine, that if a person were to sink down perpendicularly to the centre of the Earth, the Moon, if not exactly in the zenith point, would appear to rise proportionally; so that she appears somewhat lower from the surface of the Earth than she would from the centre. This is called her *parallax*, (from the Greek *paralasso*, to change place), and is dependent on her *distance* and *altitude* in the sky, from which it is easily computable. Applying this second *correction*, we reduce her observed place to her *true* place, where she would be seen from the centre of the Earth, if it were transparent. Now, her true places at different times throughout the day, by the Greenwich clock, are registered in what are called *Lunar Tables;* so that having, as above, found her true place, at the time of observation, these Tables show what the time is at Greenwich; and comparing these times gives the longitude. Thus, if we find by observation that the Moon's true place is 10 degrees from a certain star, and our Tables show that the Moon is 10 degrees from that star at six in the evening, we know that it is six o'clock at Greenwich. We have then only to compare this time, with the time of our observation, and so calculate our longitude from Greenwich as we did by means of Jupiter's satellites.—Eclipses of the sun, transits of the inferior planets, occultations of fixed stars by the edge of the Moon, all serve more or less accurately to find the longitude. Nay, a watch that keeps Greenwich time precisely, would be sufficient; as we have only to compare the time it shows with the time at the given place.

Has the Moon alone *parallax?*

All the celestial bodies are subject to parallax, except the *fixed stars*, whose immense distance, compared to which the Earth's diameter is nothing, causes them to appear exactly in the same place, whether viewed from one end or the other of that diameter, and therefore whether viewed from the surface of the earth or the centre. Nay, when viewed from opposite extremities of the diameter of the Earth's *orbit*, they appear exactly in the same place, thereby showing that *this* diameter is nothing as compared to their infinite distance. All the Planets, even those remotest from the Earth, appear in very different places when viewed from opposite points of the Earth's orbit; which difference of place is called their *annual* parallax, as the other is called their *diurnal* parallax. On the supposition that one of the brightest fixed stars had a parallax of only two *seconds*, it has been computed that its distance must be at least 200,000 times that of the Sun from the Earth. We are certain that the nearest fixed star is more than 80,000 times as far as the Sun from us; and therefore that its light would take 80,000 times 8 minutes (that is, about 400 days), in passing from it to the Earth [page 319]. Herschel concludes from his observations on the faintest *nebulæ* (collections of stars so dense as to look like *clouds*), that light from them must occupy *two millions of years* in reaching the Earth.

No wonder, observed Mrs. St. George, that the Psalmist should exclaim, "the heavens declare the glory of God."

Lest I should forget, I will here specify a *third* correction, which is frequently introduced into astronomical computations. By reason of a certain conical motion, or *twirling*, of the Earth's axis round its centre, the equinoctial points or intersections of the ecliptic and equator move backward on the ecliptic, in respect to the order of the signs, completing a whole revolution of the ecliptic in about 26,000 years; at the rate of about 1 degree in 72 years, or 50 seconds in a year. Hence, the fixed stars appear to change their positions, relatively to the equinoctial points, and allowance is often to be made for this in astronomical computations. Likewise, as the sun moving always direct, while these points move retrograde, comes round to them each year a little before he would if they were fixed, the time of each equinox will *precede* the time when it would otherwise have taken place; wherefore this allowance, or correction, is named the *precession of the equinoxes.* There are various other minute corrections used in our Science, but *refraction*, *parallax*, and *precession*, are the principal. The *obliquity of the ecliptic*, that is, the inclination of the ecliptic to the equator, is at present diminishing at the rate of *half a second* per year; but this diminution will never exceed a small quantity, and will gradually vanish as it arose, vanishing and arising successively again.

There is one other most important *correction*, gravely observed Isabel, which I beg leave to submit to your lordship's notice.

What is that? demanded Franklyn in some surprise.

That you would not perplex us any more with such ridiculous little matters about a few stray seconds here or there, but return from your *precessions* and *obliquities* to Saturn's Ring and his Satellites.

I assure you, replied Franklyn, ridiculous as these matters appear to you, they are of great moment to *Astronomers;*—but it is very natural that a young Lady should think much more about *Rings* and *Satellites* than even about the most necessary *corrections*. However; Saturn's Moons, except the sixth, require a very good telescope to render them visible, and therefore have not been attended to as much as those of Jupiter. Huygens discovered the sixth, which is called the *Huygenian*, after him; and Herschel the first and second. This latter philosopher also discovered the six satellites of the Georgium Sidus; still less, however, is known about these. As to Saturn's Ring, which was discovered by Huygens, it is, as far as we know, *unique* in our System. Herschel ascertained that it is *double*, consisting of two in exactly the same flat, but distant nearly 3000 miles. The greatest diameter of the outermost is about 200,000 miles, its width 6700, its thickness about 1000; of the innermost, the greatest diameter is 180,000 miles, and its width 19,000; so that the latter is about 160,000 miles distant from Saturn himself; on which account stars have sometimes been observed between this ring and the planet. Although probably of opaque or earthy material, these rings present a beautiful object when either illuminated directly by the Sun, or by reflection from Saturn. They become visible and invisible, perhaps twice in a year; according as their position with regard to us enables them or not to present a sufficient breadth of enlightened surface towards the Earth. Herschel conjectured that the Georgium Sidus has two rings, perpendicular to each other.

What are called *Belts*, I suppose, have some resemblance to rings, observed Eugenia.

None whatever. Jupiter's Belts are faint *shades*, somewhat of the nature of *clouds* in his atmosphere. Though in some degree changeable, they are, however, more permanent than our clouds, generally exhibiting traces, parallel to his equator, by which they are recognizable.—I have no more to say.

And have we now learned *all* Astronomy? inquired Isabel with real simplicity.

Were I to pursue this Science throughout all its details, answered Franklyn, our EVENINGS would be almost as many as the Arabian Nights. But, in these TWELVE, you have had developed a tolerably complete System of FAMILIAR ASTRONOMY.

THE END.

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