H. W. Xmas
1863 ... /£2,
exchanged for
a letter
2, H. J.

THE

ELEMENTS

OF

ASTRONOMY,

ILLUSTRATED

BY OBSERVATIONS,

Which the Student may make

ON THE HEAVENS,

AND BY THE

CELESTIAL GLOBE:

To which is added,

AN ESSAY

ON THE PLURALITY OF WORLDS.

BY JAMES MITCHELL, M.A.
Author of Elements of Natural Philosophy, Tour through Belgium, &c.

Cœlique vias et sidera monstrent,
Defectus Solis varios, Lunæque labores.---VIRGIL.

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TO

WALTER FAWKES, Esq.

Sir,

In dedicating this work to you, I am actuated by a desire to put it under the protection of a name, for which every Englishman must feel veneration and respect. Whilst so many men of your exalted station have been wasting their time and wealth in foreign lands, you have

been occupied in the active pursuits of literature and science, and in protecting the interests and liberties of your country, by which you have exhibited to the world a bright example of the habits and virtues which characterize the English gentleman. You have bestowed on living and native talent the most magnificent patronage, in your splendid collection of the works of British Artists; and have thereby manifested the purest taste, and have set an example of patriotism infinitely worthy of applause and imitation.

I am proud to acknowledge to the world the favours I have received from you, and the gratification I have felt in my former humble attempts to familiarize the Elements of Science having met with your approbation; and I beg to offer you this work, as an expression of the gratitude and respect with which

I am, Sir,

Your very obliged and

obedient Servant,

JAMES MITCHELL.

Star Life Assurance Office,
London, March 21, 1820.

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acquainted with the nature of these bodies, and the laws by which they are regulated in their motions? This liberal desire Astronomy gratifies, and becomes a source of much pleasure. As the botanist, who knows the names and qualities of the various plants he meets in the fields, has a double pleasure in his rural walks, so also the man who has some knowledge of Astronomy, when abroad at night, and in view of the starry heavens, recognises with satisfaction the planets and the constellations with whose figure he is acquainted; and feels still higher pleasure on the occurrence of comets, eclipses, or other unusual phenomena. Nor is this pleasure unaccompanied with peculiar advantage. There is an expansion of mind accompanying it, which enlarges the faculties of the soul. The mind of the ignorant ploughman, who knows merely a few villages in his neighbourhood, is dark, narrow,

and contracted, compared with the mind of that man who has mingled in the busy world, and is well acquainted with other countries as well as his own, both by observation and reading. Astronomy conducts still farther, to view our whole world as making but one planet, and that not a very large one, in a system of planets; and the whole of that system, vast as it is, only as one of the grains of sand on the sea shore, compared with the boundless extent of the vast creation of God.

Such reflections have a tendency to exalt the mind to the highest degree of piety. Thus the Israelitish king composed his most sublime psalms, the eighth and the nineteenth, after a contemplation of the wonders of the heavens. From the same subject proofs of the greatness and wisdom of God are drawn in the thirteenth of the book of Wisdom.

From nature the mind rises up to nature's God. Young has well expressed it, that

"An undevout Astronomer is mad."

Cicero proves the perfections of the Deity from the creation of the heavens. Indeed the boundless power and wisdom of Divinity are not to be seen in any other way on such a magnificent scale. Thus, when the Lord answered Job from the whirlwind, and told him of the glories of heaven, he was humbled and confounded.

As Astronomy excites true piety, so also a correct knowledge of it has removed much false religion, or superstition, which formerly prevailed in the world.

In the dark ages an eclipse struck terror little less than an earthquake. The Athenian army which besieged Syracuse was about to depart from that city, when, unfortunately for them, there happened an

eclipse of the moon.* By order of the priests they, therefore, determined to remain until the next full moon; but before that time they were overwhelmed by their enemies, and miserably perished. The Theban army, which was on its march to Thessaly, was stopped on its route by a similar cause. In 168 B.C. when the army of King Perseus was preparing to engage the Roman army, an eclipse of the moon occurred, and this [illegible] [illegible], with the [illegible], [illegible] the end of the Macedonian kingdom." Indeed, the ancient poets and historians are full of the terrors of the people due to the sight of unusual celestial phenomena, and this superstition may be traced up to the days of Homer.†

An eclipse happened on the birthday of the emperor Claudius, and it was deemed

* Thuc. VII. 50. † [illegible]

eclipse of the moon. By order of the priest, they, therefore, determined to remain until the next full moon; but before that time they were overwhelmed by their enemies, and miserably perished. The Theban army, which was on its march to Thessaly, was stopped on its route by a similar cause. In 168, A.C. when the army of king Perseus was preparing to engage the Roman army, an eclipse of the moon occurred, and this direful presage, says the historian, put an end to the Macedonian kingdom.* Indeed, the ancient poets and historians are full of the terrors of the people on the sight of unusual celestial phénomena, and this superstition may be traced up to the days of Homer.†

An eclipse happened on the birth-day of the emperor Claudius, and it was deemed

* Justin, xxxiii. c. 1. † Homeri Ilias, iv. l. 75.

necessary by the government, in order to quiet the terror and uneasiness of the people, to have an account of the nature and cause of the phenomenon published.

It was not an unusual opinion at an eclipse of the moon, that she was at the time attacked by some monster who was devouring her. The priests of Cybele, therefore, made as much noise as possible, with cymbals and by shouting, in order to frighten the monster away. Voyagers tell us of savage nations who still do the same.

In September, 1186, when the planets were all in conjunction, or near one another in the heavens, Jews, Christians, and Mahometans were in equal terror.

Such superstitious dread is now, we may hope, for ever dissipated; but there are still delusions among the ignorant, which, but for the diffusion of the knowledge of Astronomy, would be much more general.

A belief of the power and influence of the heavenly bodies to determine the actions of all mortals, becoming universally entertained; and it is only in our enlightened age that it is [illegible] of the [illegible] in society. The more ignorant the country the more [illegible] such a superstition to be [illegible].

In 1769 the [illegible] Sultan of Turkey, [illegible] France to [illegible] the [illegible] [illegible] and [illegible] the study [illegible] [illegible] He [illegible] [illegible] [illegible] and [illegible] [illegible] [illegible] of the [illegible] [illegible] of the Astrologer. [illegible] [illegible] [illegible] they [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] and [illegible] of the principles of the science.

As the [illegible] [illegible] [illegible] [illegible] [illegible] the study of Astronomy, it is [illegible] [illegible] to [illegible] those [illegible] and [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible]

necessary by the government, in order to quiet the terror and uneasiness of the people, to have an account of the nature and cause of the phenomenon published.

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In September, 1586, when the planets [illegible] in conjunction, [illegible] the Saturn, Jupiter, [illegible] and the [illegible] went [illegible] tears.

Such superstitions should be [illegible] be for ever dissipated; but there are [illegible] among the ignorant, which the diffusion of the knowledge of astronomy would be much more [illegible]

A belief of the power and influence of the heavenly bodies to determine the actions of all mortals, was long universally entertained; and it is only in our enlightened age that it is confined to some of the lowest in society. The more ignorant the country the more likely is such a superstition to be received.

In 1762 the emperor Selim, of Turkey, sent to France to obtain the works of the Academy, and chiefly the works on Astrology. It probably surprised him, and perhaps greatly lessened his opinion of the wisdom of the Academicians, when he was told that they composed no works on that subject, and utterly disbelieved the utility and stability of the principles of the science.

As the mind is exalted above dark superstition by the study of Astronomy, it is also likely to be elevated above gross and mean pleasures. Pythagoras had an inscription

over the door of his school—" Οὐδεὶς ἀγεωμέτρητος εἰσιτῶ."

The taste produced by the study of the mathematics he considered as a necessary preparative to the study of philosophy. Anaxagoras said he was born to study Astronomy. Plato had the highest opinion of it.

To the literary man a knowledge of Astronomy must prove gratifying, as it enables him to understand the works of ancient and modern poets, historians, and orators, in which allusions are made to astronomical subjects. The ancients not having their calendar regulated by the accumulated experience and science of former ages, were obliged to mark and ascertain the return of the different seasons by an observation of the heavenly bodies. Hence the rising and setting of the principal stars, and other ordinary phenomena of the heavens were generally

known, and to a person unacquainted with these subjects, many parts of their works must be unintelligible. Milton in many passages derives the finest and most sublime ideas from Astronomy. Others have also drawn much illustration and ornament from the same source.

In the ordinary business of human life, a knowledge of Astronomy may sometimes be turned to account. By knowing the North Pole star, we can at all times at night tell what direction is north, and hence we know the south, east, and west, with the intermediate points. In walking over a large plain covered with snow, or in sailing on the water at night, this may prove useful; and in the various accidents which befall a person who makes voyages to foreign climes, it may be of inestimable benefit.

Before the invention of the mariner's compass, the Arabian merchants found their

enter the door of his school——" (Ουδεις αγεωμετρητος εισιτω.)

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Before the invention of the mariners' compass, the Arabian caravans found their

way through the desert at night by observing the stars.* Ancient navigators entirely depended upon them, when without sight of land.†

These are some advantages an individual may obtain by himself studying Astronomy; but there are other important advantages which the science has conferred on mankind, and which are obtained by a certain number of persons applying themselves to the study for the benefit of society. The real situation of places on the globe has been ascertained by it, and correct maps have been made thereby. Toledo in Spain, and Grand Cairo in Egypt, were in ancient maps made 53° distant from each other, whereas they ar e only 35°. Even in Britain great corrections have been made by means of the

* Koran. Diodorus Siculus.

† Virgil, Æneid iii. l. 515. Homer's Odyssey, v. Acts o the Apostles, xxvii. v. 19, 20.

Trigonometrical survey. In navigation, by means of knowledge and assistance derived from Astronomy, the sailor finds in what place he is, when in the midst of the ocean, and can find his way to any desired port. Hence all the wealth which commerce and foreign voyages procured to Europe.

By the construction of the calendar, we have our domestic almanacs, and know beforehand the seasons of the year, which the [illegible], without looking at the heavenly state of the weather, or being obliged [illegible] to watch the rising and setting of the stars. Hence clocks and watches have been perfected to great degrees of exactness and accuracy, which adds greatly to the facilities of business, and the regularity of the affairs of life.

The study of history has been promoted by Astronomy, and many dates have been

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By the construction of the calendars, we have our common almanacs, and know beforehand the seasons of the year which approach, without judging by the uncertain state of the weather, or being obliged individually to watch the rising and setting of the stars. Hence clocks and watches have been regulated to great degrees of certainty and accuracy, which adds infinitely to the facilities of business, and the regulation of the affairs of life.

The study of history has been promoted by Astronomy, and many dates have been

ascertained, by calculating the time when eclipses and other celestial phenomena recorded in history have occurred.

Thus it is known that the birth of Jesus Christ occurred four years before the vulgar æra; for Josephus tells us, that Herod died after an eclipse of the moon, which astronomers ascertain to have been four years before the time usually supposed to be that when Christ was born. M. Costard calculated the time of the eclipse which happened in the war between the Lydians and Medes, and found it to be six hundred and three years A. C. and by another calculation he ascertained that the expedition of Xerxes was four hundred and seventy-eight years A. C.

THE

ELEMENTS

OF

ASTRONOMY,

&c. &c.

OF THE DIURNAL MOTION OF THE HEAVENLY BODIES.

THE SUN being the most brilliant by far of the heavenly bodies, his apparent motion is that which is most familiarly known. He rises on the eastern side of the horizon, ascending higher and higher in the heavens, and at last, at 12 o'clock, he comes exactly south, when he is at his greatest height; he then gradually descends and, at last, sets in the west. It is to be observed, that the same time intervenes

between sun-rising and 12 o'clock, as between 12 o'clock and sun-set. Also, if it be observed at what point in the east the sun rises, and how far that is from the north point of the horizon, it will be seen that he sets in the west at the same distance from the north.*

The MOON has a diurnal motion exactly similar to that of the sun. She rises in the east, gradually advances to the south, and then descends and sets in the west. The same time which intervenes between the moon's rising and her coming to the meridian, or being exactly south, intervenes betwixt her being exactly south and her setting. Also the same distance from the north or south at which she rises, will she be from the north or south when she sets.

The PLANETS and FIXED STARS have

* This is not precisely true, for when the day is lengthening there will be a little longer time from 12 o'clock to sun-set, than from sun-rise to 12 o'clock, and the point of the horizon where he sets will be a little nearer the north; so also *vice versâ*.

in impossibly distant regions, in every respect similar to that of stars and suns.

Stars are scattered throughout infinite space in every direction. There are many stars up in the heavens during the day as well as at night, although we do not see them on account of the brilliancy of the sunlight. The feeble light of a candle cannot be seen during the day at a distance on account of the superior light of the sun. If we observe the heavens [illegible] evening [illegible] the sun has set [illegible] [illegible], and afterwards, as [illegible] the fainter [illegible] [illegible] the twilight of the evening the brighter stars are first of all seen, then as the light of the twilight diminishes smaller stars are seen, and at last the whole of those which are visible to the naked eye. In the time of moonlight many of the smaller stars are not seen. It is clear from these observations that there are stars in the heavens in the day-time, as well as at night, which are not seen, merely from the far greater brilliancy of the sun's light. It is only by

between sun-rising and 12 o'clock, as far before 12 o'clock and sun-set. Also, if it be observed at what point in the east the sun rises, and how far that is from the north point of the horizon, it will be seen that he sets in the west at the same distance from the north.

The Moon has a diurnal motion exactly similar to that of the sun. She rises in the east, gradually advances to the south, and then descends and sets in the west. The mean time which intervenes between her rising and her coming to the [illegible] is the same [illegible] between her being exactly south and her setting. Also she is the same distance from the north or south at which she rises, that she is from the north or south when she sets.

The PLANETS and FIXED STARS have

[illegible]

Clouds - falling stars -
Meteors -

an apparent diurnal motion, in every respect similar to that of the sun and moon.

Stars are scattered throughout infinite space in every direction. There are stars above us in the heavens during the day, as well as at night, although we do not see them on account of the brilliancy of the sun's light. The feeble light of a candle cannot be seen during the day at a distance on account of the superior light of the sun. If we observe the light of the morning advancing, the smaller stars first disappear, and afterwards at sun rise, the larger stars also become invisible. In the twilight of the evening the larger stars are first of all seen, then as the light of the twilight diminishes smaller stars are seen, and at last the whole of those which are visible to the naked eye. In the time of moon-light many of the smaller stars are not seen. It is clear from these observations, that there are stars in the heaven in the day-time, as well as at night, which are not seen, merely from the too great brightness of the sun's light. If we observe

the stars on the eastern side of the horizon, and take notice of those on the western side, and then an hour after observe the same parts of the heavens, the stars on the eastern side will have risen higher, several new stars will have risen which before were not to be seen; and, on the other hand, on the western side several stars before observed will now be gone down, and others will be seen in the horizon which before were higher up in the heavens. If again, an hour after this, the student observe the heavens, he will find new stars risen in the east, and the stars formerly observed got farther on towards the west, and many sunk below the horizon. In short, the whole of the heavenly bodies have an apparent diurnal motion, like that of the sun; rising in the east, and advancing in the heavens till they come to the south or meridian, and then descending towards the west where they set. If any one star be observed at its rising, and in its progress, it will be found to take the same time from rising to coming to the meridian as from descending from the meridian to

the west. Also it will set in the west exactly as far from the south as the point was distant from the south at which it rose.

In consequence of the diurnal motion, if a telescope be directed towards any heavenly body, it will soon pass across the disk and disappear on the western side; and to keep the heavenly body in view, the telescope must be constantly moved to be in a direction towards it. If the telescope remain at rest, new stars will be observed to come in view, pass across the disk, and disappear.

There are stars towards the north of the heavens which never set, being, however, lowest down when towards the north, and highest up when on the meridian. This will be illustrated by the celestial globe. Let it be rectified for the latitude of the place, which for London is 51½°, that is, let the north pole be elevated 51½° above the horizon with the North Pole towards the north of the horizon, and let the globe be turned round from east to west, it will be seen what stars never set at London.

The student ought to know the North

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Stars which never [illegible]

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Different stars at different seasons –

Polar star, which will be useful for many purposes, and amongst others he may always be able to tell the north, south, and other points of the compass at night, when he sees this star, which is always about due north. If the student knows the constellation called Ursa Major, or Charles's Wain, and in some places is called the Plough, he may easily find the Polar star. A line drawn through the two principal stars, or the handles of the Plough, will point to the Pole star, which is the star at the end of a constellation, smaller indeed, but very much like it in appearance, called Ursa Minor. Now this Pole star is almost exactly at the North Pole, or that part of the heavens which would be touched by the pole of the earth, produced and extended so far. The apparent motion of the stars arising merely from the real motion of the earth, as our North Pole is at rest, so also the North Pole of the heavens appears to be at rest, whilst the constellations revolve around it exactly in the manner as may be seen by turning round the celestial globe.

It was this star which was of so much utility in navigation before the invention of the mariners' compass, and was first observed with a view to conduct ships through that sea by the [illegible].

The diurnal motion of the sun, planets, [illegible], and fixed stars, may be represented upon the whole by performing problems on the celestial globe.

Thus to represent the sun's diurnal motion for May 1st.

On the horizon of the globe it will be seen that his place is the 11th of ♉. Elevate the North Pole 51½° for the latitude of London, and find the 11th of ♉ in the ecliptic, and bring it to the meridian and set the index to XII. Then bring 11° of ♉ to the western side of the horizon. It will be seen that the point where the sun rises is about 22° north, and that the index is [illegible] minutes past [illegible] or seven hours 25 minutes before 12 o'clock. Bring the sun's place 11° of ♉ to the western side, where he sets, and it will be found to be about 22° north, and the time ascertained by the index 25 minutes past seven.

Pole-star, which will be useful for many purposes, and amongst others he may always be able to tell the north, south, and other points of the compass at night, when he sees this star, which is always about the north. If the student knows the constellation called Ursa Major, or Charles's Wain, and in some places is called the Plough, he may easily find the Polar star. A line [illegible] through the last principal stars, or [illegible] of the Plough, will point to the Pole star, which is the last of the [illegible] of a constellation, smaller, indeed, but [illegible] like it in appearance, called Ursa Minor. Now this Pole star is almost exactly at the North Pole, or that part of the heavens which would be touched by the pole of the earth, produced and extended to it. The apparent motion of the stars arising wholly from the real motion of the earth, as our North Pole is at rest, so also the North Pole of the heavens appears to be at rest, while the constellations revolve round it exactly in the manner, as may be seen by turning round the celestial globe.

It was this star which was of so much utility in navigation before the invention of the mariners' compass, and was first observed with a view to conduct their ships through the sea by the Tyrians.

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In the same manner it may be shown for any other day of the year.

Supposing the moon to be in 25° of ♊. The pole being elevated 51½° as before, it will be found that the moon rises from east 40° north, is eight hours and a quarter in coming to the meridian, and an equal time in descending to the western horizon, where she sets west 40° north.

Sirius will be found to rise from east 27° south, to take four hours three quarters to come to the meridian, an equal time to descend, and will set also west 27° south.

The first step in the study of Astronomy ought to be, to impress clearly on the mind the apparent motion of the heavenly bodies, and *actually to observe it in the real heavens.* It will be to no purpose to learn particulars of bodies of which little or no idea is entertained, except that of figures engraved upon paper; yet too frequently mere trifling of that sort arrogates to itself the name of the study of Astronomy.*

* The author is well aware, from his professional experience, how readily this principle will be admitted

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* [illegible]
[illegible]

The apparent motion of the heavenly bodies, from east to west, is caused by a real motion of the earth upon her axis from west to east. As the earth turns round, the objects which disappear are seen last on its western side, and the objects which come in sight are first seen by the spectator towards the east, and sun, moon, planets, fixed stars, and comets, in their apparent places in the vast vault of heaven, from one and the same cause, all appear to have one and the same kind of motion.

The very youthful student ought to be told, that though these bodies all appear to the eye to be about the same distance from us, they are placed at distances exceedingly different. The moon is about 240,000 miles

by the ladies and gentlemen who devote part of their leisure hours to the acquisition of a knowledge of the elements of science; and how seldom their indolence will allow them to put it in practice. Unless, however, the *real heavens* be observed, very indistinct ideas will be formed of celestial phenomena, and difficulty will be experienced, where otherwise every thing might be simple and easy.—*Verbum sapienti.*

from us; the sun is 400 times as far; the planets are at various distances, three of them sometimes nearer us than the sun, and sometimes farther off, the other planets are much farther: the fixed stars are all at a distance so infinitely great, that the distance of the sun is but as the point of a needle compared to it.

That apparent blue vault of heaven, which we see, is not a solid substance, but merely a vast, void, empty space, throughout which nature has placed the different bodies. It appears blue in the day-time from the reflection of some of the particles of light from the atmosphere. Were there no atmosphere around the earth, the colour would be merely black, or the absence of light. At night, when the rays of the sun do not visit us, we see that the heavens appear quite black.

A very little reflection will satisfactorily prove that the diurnal motion of the heavenly bodies is merely *apparent*, and caused by the real motion of the earth on her own axis. The same appearances would arise

which the sun, moon, [illegible], [illegible] have [illegible] [illegible] round the earth in [illegible] [illegible] [illegible] [illegible] [illegible] remained [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible]. We may [illegible] [illegible] [illegible] that the [illegible] [illegible] [illegible] which [illegible] [illegible] place. [illegible] [illegible] [illegible] [illegible], [illegible], and [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] in a [illegible] time, and that [illegible]. We [illegible] [illegible] [illegible] to [illegible] that [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]; and [illegible] of the [illegible] and [illegible] the [illegible] on the [illegible], [illegible] [illegible]

distant ninety-six millions of miles; were he then to perform a revolution around the earth in one day, he would have to travel at the rate of three thousand five hundred miles in a second. But the planet Herschel, in that part of his orbit which is farthest from the earth, is twenty times as far distant, and would, therefore, have to travel within the same time seventy thousand miles in a second, which is about five or six hundred thousand times as fast as a cannon-ball. But the distance of the stars is so great, that the distance of the sun compared with it is but as the point of a needle, and they are suns like our sun, and more numerous than the sand of the sea; and to suppose that so many boundless worlds should in twenty-four hours perform a journey so vast, and with a rapidity swifter than light itself, to revolve round our little globe, would be infinitely absurd, and we cannot entertain the smallest possible doubt that the apparent diurnal motion of the heavenly bodies is caused by the revolution of the earth on its own axis.

Illusions as to motion.
of man floating down a stream
going along between hedges

Apparent diameter of ☉ greater or less according Distance.

OF THE SUN AND HIS APPARENT MOTION.

THE mind being rendered familiar with the diurnal motion of the heavenly bodies, the annual motion of the sun is next to be considered. When the sun is above the horizon most of the heavenly bodies disappear, and the mind which has not been familiarised with the study of Astronomy, is apt to suppose that no stars are then in the heavens; but they are there, and were the sun to be veiled they would appear. This has actually been the case, when there has been a total eclipse of the sun, by the moon coming between us and him, and intercepting the whole of his light, and the stars have appeared as distinctly as at midnight; but the moment the moon has passed over, and a glimpse of the sun's beams has shone out, from the superior brilliancy of his light, their feeble light has been undistinguishable

Greatest apparent diameter 0°.60358
Least 0°.58370

and they have been, therefore, no longer seen.

With a very good telescope the large stars may be seen in the day-time, but it is a difficult operation. From the bottom of a very deep draw-well, to which no part of the sun's rays can reach, such large stars as might be directly over head would be visible. Thus, also, the stars are said to be seen from the bottom of some mines. The sun therefore goes on through the heavens with stars on every side of him, during the day, although they are unseen, precisely in the same manner as the moon, whose rays are not so powerful as to extinguish the brightness of her attendants. Now the sun has an annual motion amongst these stars, which must be clearly understood. Were we able to see the stars near the sun to day, and take notice of those behind him, or to the east of him, and were we a month after to look at them, we should see that he was fallen back behind those which had been behind him, or to the east of him; and were we again to make an observation a month after, we should see that he was

not falling behind, and were these observations continued for twelve months, we should find he had made a progress round the heavens. New observations were made by mankind at a very early period, and in the manner following. It was observed what bright stars were near the sun [illegible] in the eastern part [illegible] the sun rose, and those [illegible] where he was in [illegible]. It was also observed what stars were visible after sun set, and [illegible]. In a month after it was [illegible] the same stars [illegible] were [illegible] before. The sun was a long time before him, and that some other stars intervened, so that he had fallen back all that [illegible]. It was seen after the [illegible] which had been a long way behind, and [illegible] they were [illegible]. At this season [illegible] the ecliptic, [illegible] circular path through the heavens, [illegible] by [illegible].

By these and subsequent observations [illegible] it was supposed that the sun, in [illegible] the [illegible] of the [illegible] of [illegible]

and they have been, therefore, no longer visible.

With a very good telescope the larger stars may be seen in the day-time, but it is a difficult operation. From the bottom of a very deep draw-well, in which no part of the sun's rays can reach, such large stars as might be directly over head would be visible. Thus, also, the stars are said to be seen from the bottom of some mines. The sun therefore goes on through the heavens with stars on every side of him during the day, although they are unseen, precisely as the stars [illegible] to the moon, [illegible] are said to [illegible] to be [illegible] the brightness of her atmosphere. From the [illegible] motion amongst these stars would [illegible] be clearly understood. Were it possible to see the stars near the sun in any one [illegible] of those behind him, at [illegible] end of [illegible] a month after, we should see that he was [illegible] some [illegible] those which had been [illegible] of him at the end of [illegible] and [illegible] to make his observations [illegible], we should see that he was [illegible]

before Sun rising

still falling behind; and were these observations continued for twelve months, we should find he had made a progress round the heavens. Now observation was made by mankind at a very early period, and in the manner following. It was observed what large stars were near the eastern side of the horizon just before the sun rose, and near to where he was to rise. It was also observed what stars were visible after sun set, and near where he set. In a month after it was seen, that at his rising the stars which had risen but just before him now rose a long time before him, and that many other stars intervened, so that he had fallen back all that space; and at his setting it was seen that the stars which had been a long way behind him were now very near him. In this manner was the ECLIPTIC, or sun's annual path through the heavens, ascertained by observation.

By close and accurate observation astronomers have clearly determined that the sun, in passing round the heavens in the course of one year, does not go over precisely an

equal space on every day, but at that period when his diameter appears a little larger than usual, he moves rather faster, and at some times he moves rather more slowly.

It would be enjoining perhaps too heavy a task on the student to expect him to make a similar observation; but, if he live in the country, where he has an advantage which but very few enjoy in town, of being able to take an extensive view of the heavenly bodies every clear evening, he may have perseverance enough to observe the course of the moon. The moon's path is not precisely the same as that of the sun, but it is nearly so, and if the student observe near what star the moon is any evening; and, look at her the following evening, he will see she has fallen back a considerable way, and still more by the next evening, and in the course of about 27½ days, she will have completed her tour round the heavens, and described in that time the same path which the sun does in the course of one year. The student, when he traces the moon's path in the heavens, from evening to evening, *ought to find these*

equal spaces on every day, that at that portion which his direction appears a little longer than usual, he moves rather faster, and at other times he moves rather more slowly.

It would be imposing perhaps too heavy a task on the student to expect him to make a similar observation; but if he lives in the country, where he has an advantage which but very few enjoy in towns, of being able to take an extensive view of the heavens, he may every clear evening, he may have perseverance enough to observe the movements of the Moon. The moon's path is not precisely the same as that of the sun, but it is always near it, and if the student observes one of the [illegible] the moon is any [illegible] given hour, look at her the following evening, he will [illegible] [illegible] been a considerable way, and still more the next [illegible], and in the [illegible] [illegible] [illegible] days, she will have completed her circuit round the heavens, and travelled in that time the same path which the sun does in the course of one year. [illegible] when he begins his nightly watch of the heavens, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

stars also on his celestial globe, and thus he will have a much clearer idea of the ecliptic than barely by reading books and looking at engraved plates.

The planets in different periods of time move round the heavens from west to east, in paths never departing far from the ecliptic, not more than eight degrees on the one side or on the other. This space on each side of the ecliptic is called the zodiac, and has been divided into twelve parts, called signs, corresponding with the twelve months of the year.

As the sun was supposed to pass through the heavens in 360 days, the circle of the ecliptic was divided into 360 degrees, and, in conformity to the division of twelve months in the year, these were divided into twelve signs, of thirty degrees each. These signs are called in Latin and English as follows:

♈ Aries	The Ram, which the Sun enters	March	20
♉ Taurus	The Bull	April	20
♊ Gemini	The Twins	May	21
♋ Cancer	The Crab	June	21
♌ Leo	The Lion	July	23

♍ Virgo	The Virgin	August	23
♎ Libra	The Balance	Sept.	23
♏ Scorpio	The Scorpion	October	23
♐ Sagittarius	The Archer	Novem.	22
♑ Capricornus	Capricorn	Decem.	22
♒ Aquarius	The Water-bearer	January	21
♓ Pisces	The Fishes	Feb.	19

It is believed that these signs were first named by the Egyptians, who ascribed to them the names of such animals as, from different reasons, they thought most appropriate.

♈ Aries, or the Ram, was so named because, at the 20th of March, when the sun enters this sign, lambs began to be brought forth in numbers. ♈ The symbol is the figure of the Ram's horns. Jupiter Ammon was worshipped under the figure of a ram.

♉ Taurus, or the Bull, was so named because calves were most frequently brought forth in this month. The symbol ♉ is the face and horns of the bull.

The god Apis, who was worshipped by the Egyptians under the figure of a bull, is sup-

23 Virgo......The Virgin ....August [illegible]
24 Libra......The Balance ....Sept. [illegible]
25 Scorpio....The Scorpion ....October [illegible]
26 Sagittarius..The Archer ....November [illegible]
27 Capricornus Capricorn ....December [illegible]
[illegible] Aquarius ..The Water-bearer ....January [illegible]
[illegible] Pisces ....The Fishes ....Feb. [illegible]

It is believed that these signs were first named by the Egyptians, who ascribed to them the names of such animals as, from different reasons, they thought most appropriate.

Aries, or the Ram, was so named because, at the 20th of March, when the sun enters this sign, [illegible] to be brought forth in abundance. The symbol is the figure of the Ram's horns. Jupiter Ammon was worshipped under the figure of a ram.

Taurus, or the Bull, was so named because calves were most frequently brought forth in this month. The symbol is the face and horns of the bull.

The god Apis, who was worshipped by the Egyptians under the figure of a bull, is supp-

posed to have been intended on the globe. The Greeks considered the bull as a figure of the one which carried off Europa.

Within the bounds of this constellation are some remarkable stars. Aldebaran, and several others near him, have had the name of Hyades, and were supposed to bring rain. They are called the Tristes Hyades in Virgil. They have been supposed to represent the daughters of Atlas. The Pleiades, or seven stars, so called from Πλειν, to sail, because when the sun was near them, it was the proper time to draw down the ships which had been laid up during the winter. Homer and Attalus Geminus speak of six of them; but Aratus, Hipparchus, and Ptolemy, mention seven. One of them is now not to be seen, and is one of the stars which is lost from the heavens.

♊ Gemini, or the Twins, were marked on the Egyptian globes by two young goats, for a similar reason as the two former signs. The Greeks changed the two goats into the figure of Castor and Pollux, the twin sons of Leda. ♊ The symbol denotes friendship.

γ and δ in this constellation, according to ancient fables, are the two asses whose cries assisted Jupiter in his wars with the giants.

♋ Cancer, or the Crab, was so named because the sun, on entering into that constellation, had arrived at his greatest northern declination, and was now about to go backwards. ♋ The symbol denotes the claws of the crab. On ancient monuments in Egypt this sign is denoted by Mercury and Anubis and his dog, which had the head of a man.

♌ Leo, or the Lion. As the sun enters this sign on the 23d of July, he passes through it in the hottest season of the year. The figure of a lion, the fierce inhabitant of warm climes, was deemed emblematical of this heat. At this time the Nile overflowed Egypt, and the figure of a lion's head was usual on the gates which opened the canals. The symbol is the rump and tail of the lion.

♍ Virgo, the Virgin, was intended by the Egyptians to represent the goddess Isis. Among the Greeks this was changed into

Ceres, the goddess of corn, and a stalk of corn was added. The symbol is a corrupted representation of three heads of corn.

♎ Libra, or the Balance, was at first a constellation and sign marked by the long claw of the Scorpion, the following constellation. In the time of Augustus Cæsar, in compliment to the justice of his government, the figure of a balance was here placed.

> Anne novum tardis sidus te mensibus addas
> Qua locus Erigonen inter Chelasque sequentes
> Panditur; ipse tibi jam brachia contrahit ardens
> Scorpius, et cœli justa plus parte relinquit.
>
> VIRGIL, Georg. I. 32, &c.

As the day and night are equal at the time the sun enters this sign, the balance is a very proper emblem also on that account.

♏ Scorpio, or the Scorpion, is supposed to have been so named because it was in Egypt a sickly time of the year. It was dedicated to Typhon, the brother of Osiris, who was sent by Diana against Orion. The

sting in the tail of the symbol ♏ is emblematic of the scorpion.

♐ Sagittarius, or the Archer, is supposed to have been given as the name to this sign, as it was a month adapted for hunting. On ancient obelisks the emblem ♐, an arrow, is sometimes seen. It is supposed that Hercules was the figure on the Egyptian globe, but the Greeks changed it into Chiron, the Centaur, the preceptor of Jason, Æsculapius, and Achilles. This fabulous figure, compounded of a horse and a man, is retained upon our globes.

♑ Capricornus, Capricorn, or Goat, was made the emblem of this sign, because the sun, having now got to the farthest distance and lowest declination, begins to come north, and consequently to be higher and higher every successive day. This is emblematically represented by a goat, an animal fond of climbing up the sides of rocks. The figure of a common goat was often represented on the globe; but that of Pan, the fabulous deity in part composed of that animal, in the attitude of plunging into the

Nile, to escape from Typhon, was substituted by the Greeks. The symbol [illegible] represents the goat's horns.

11. Aquarius, or the Water-bearer, is supposed to have been put, from the necessity which would in that month begin to be felt, of watering the [illegible] in the gardens, the water from the [illegible] of the Nile having [illegible] in Chaldæa and Arabia, this would be eight weeks [illegible] than in Egypt. [illegible] to the Egyptians and [illegible] the [illegible] in which they [illegible] water [illegible]. The [illegible] of the sign was called by the Greeks Ganymede, Jupiter's cup-bearer. The symbol [illegible] evidently represents waves of water.

12. Pisces, or Fishes, are the last sign. On some ancient monuments there have been found fishes, dedicated to Neptune [illegible] Egyptian [illegible] of the sea. Some suppose there was [illegible] the figure of Venus and her son throwing themselves into the water to escape from Typhon. The symbol is [illegible] to represent two fishes, and the figure of two fishes is on the globe.

sting in the tail of the symbol ♏ is emblematic of this weapon.

♐ Sagittarius, or the Archer, is supposed to have been given as the name to this sign, as it was a month adapted for hunting. On ancient globes the emblem, an arrow, is sometimes seen. It is supposed that Hercules was the figure on the Egyptian globe, but the Greeks changed it into Chiron, the Centaur, the preceptor of Jason, Æsculapius, and Achilles. This fabulous figure, compounded of a horse and a man, is retained upon our globes.

♑ Capricornus, Capricorn, or Goat, was made the emblem of this sign, because the sun, having then got to the farthest distance, and lowest declination, begins to ascend, and consequently to be higher and higher every successive day. This is emblematically represented by a goat, an animal fond of climbing up the sides of rocks. The figure of a common goat was often represented on the globes, but that of Pan, the fabulous deity in part composed of this animal, in the attitude of plunging into the

Nile, to escape from Typhon, was substituted by the Greeks. The symbol ♑ represents the goat's horns.

♒ Aquarius, or the Water-bearer, is supposed to have been put from the necessity, which would in this month begin to be felt, of watering the shrubs of the garden, the water from the overflowing of the Nile being now dried up. In Chaldea and Arabia this would be still more necessary than in Egypt. Plutarch tells us the Egyptians had a festival at this season, in which they poured water into the sea. The figure on the globe was called by the Greeks Ganymede, Jupiter's cup-bearer. The symbol ♒ evidently represents waves of water.

♓ Pisces, or Fishes, are the last sign. On some ancient monuments have been found fishes, dedicated to Nephthis, the Egyptian god of the sea. Some have said there was anciently the figure of Venus and her son throwing themselves into the water to escape from Typhon. The symbol ♓ is meant to represent two fishes, and the figure of two fishes is on the globe.

The Ecliptic may with some degree of accuracy be traced by the eye in the heavens, by means of some large stars near it. Not far from the seven stars are the Hyades, the largest of which is Aldebaran, which is the eye of the Bull in the constellation Taurus ♉, a little south of the ecliptic. To the north-west of this star, at some distance, is the chief star of Aries ♈. To the north-east of Aldebaran are Castor and Pollux, two large stars, the principal of the Gemini ♊. Regulus, or the Lion's Heart, is on the ecliptic. The Virgin's Spike is a very large star, almost on the ecliptic, being a little south of it. Antares, or the Scorpion's Heart, is also a little south of the ecliptic; and much farther to the east is Fomalhaut, or the Southern Fish, some way south from the ecliptic. Several of these stars are always above the horizon, and, when once known, the line of the ecliptic may easily be traced.

The distance of the sun, or any heavenly body proceeding to the east from the first of Aries, counted on the ecliptic, is called the

LONGITUDE. The distance north or south of the ecliptic is called the LATITUDE.

Were a line to be drawn round the heavens at exactly an equal distance from the north and south poles, it would be the Equator of the heavens; or were the plane passing through the equator and centre of the earth to be continued on to the stars, it would also exactly coincide with this equator. The equator and ecliptic intersect each other at two points, the first of Aries and the first of Libra. The angle made by this intersection, called the Obliquity of the ecliptic, is calculated to be on the first of January, 1820, 23° 27′ 57″, 8. This angle in the beginning of 1769 was calculated by Dr. Maskelyne to be 23° 28′ 10″. It is gradually diminishing; but it is shown by La Place that, after a certain number of years, it will begin again to increase, and, having attained its maximum, will after that again diminish. The distance of the sun or any other heavenly body from the equator, either north or south, is called the DECLINATION. The sun's declination varies every day, as

he moves along the ecliptic, and when he is at either of the tropics is 23° 27′ 57″, 8. The distance of any heavenly body from the first of Aries, counted on the equator, is called the Right Ascension.

The student who examines his celestial globe will be at first surprised not to find the boundaries of the twelve signs to correspond with the boundaries of these twelve constellations. They did so when the celestial globe was made by Hipparchus, about 120 A.C. and the first of Aries, in which the sun entered on coming to the equator, in the vernal equinox, was the beginning of the constellation of Aries; but every successive year the sun has come to the equator, at a point a little more to the west than the preceding. This progress is exceedingly slow, about 50⅓″ in a year, or a sign of 30° in 2145 years; so that the first of Aries is now a sign more to the west than the star γ of the constellation Aries. In the course of 25,740 years the beginning of Aries will be where it was in the time of Hipparchus.

In consequence of the precession of the equinox, the sun arrives again at the equator a little sooner than he arrives again at any particular star. Hence the solar year and the sidereal year are not precisely the same. The solar year consists of 365 days 5 hours 48 minutes 49½ seconds, while the sidereal year consists of 365 days 6 hours 9 minutes 11½ seconds, which is 20 minutes 22 seconds more.

In a temple of [illegible], the zodiac [illegible] tars in Egypt, were not long since discovered, [illegible] two zodiacs, in which the sun is placed at the vernal equinox, in [illegible] [illegible]; these therefore must have been made about [illegible] years ago, and prove the antiquity of the science of astronomy.

About the [illegible] a [illegible] found in [illegible], where the sun is placed in Leo, at the summer solstice, [illegible] a [illegible] of the first [illegible] could not have lived at any time [illegible] than [illegible] years ago. Such [illegible] [illegible] and [illegible] that the [illegible] of [illegible], that astronomy was studied by the [illegible] [illegible], was well founded, [illegible] [illegible]

he moves along the ecliptic, and when he is at either of the tropics is 23° 27′ 48″. The distance of any heavenly body from the first of Aries, counted on the equator, is called the Right Ascension.

The student who examines his celestial globe will be at first surprised not to find the boundaries of the twelve signs to correspond with the boundaries of those twelve constellations. They did so when the celestial globe was made by Hipparchus, about 130 B.C.; and the first of Aries, to which the sun returned on coming to the equator at the vernal equinox, was the beginning of the constellation of Aries; but since then, each year the sun has come to the equator at a point a little more to the west than the year before. This progress westward has been about 50″ in a year, or a sign of 30° in 2160 years; so that the first of Aries is now a sign more to the west than the star α of the constellation Aries. In the course of 25,920 years the beginning of Aries will be where it was in the time of Hipparchus.

In consequence of the precession of the equinox, the sun arrives again at the equator a little sooner than he arrives again at any particular star. Hence the solar year and the sidereal year are not precisely the same. The solar year consists of 365 days 5 hours 48 minutes 45½ seconds, whilst the sidereal year consists of 365 days 6 hours 9 minutes 14½ seconds, which is 20 minutes 29 seconds more.

In a temple of Den-dera, the ancient Tentyra in Egypt, were not long since discovered two zodiacs, in which the sun is placed at the summer solstice, at about 24° of Cancer; those therefore must have been made about 3800 years ago, and prove the antiquity of the science of astronomy.

There was a zodiac found at Esne, where the sun is placed in Leo, at the summer solstice, in a place of the heavens where he could not have been at any time since about 5400 years ago. Such zodiacs give us reason to believe that the traditions of historians, that astronomy was studied by the antediluvians, are well founded, as these may

be believed to have been copies of zodiacs made at a former period.

A little observation will show that the sun rises at a different point in the horizon at different times of the year, arrives to very different degrees of height when at the meridian, and makes a proportional difference in the length of the day. If at London the sun be observed, when rising at the shortest day he will be 40° from east towards the south, at mid-day he will be but 15° above the horizon, and the length of the day will be only seven hours and a half. At the vernal equinox, or 21st of March, the sun rises exactly east, comes to the meridian 38½° above the horizon, and the length of the day is twelve hours. At the longest day, or 21st of June, the sun rises 40° from the east towards the north, at mid-day is 62° above the horizon, and the length of the day is sixteen hours and a half. These phenomena may be shown by rectifying the globe for the latitude, and bringing the sun's place for any given day to the meridian, and then setting the index to twelve; after that bring-

be believed to have been capable of [illegible] [illegible] at a former period.

A little observation will show that the sun rises at a different point in the horizon at different times of the year, arrives at very different degrees of height when at the meridian, and makes a proportional difference in the length of the day. If at London the sun be observed when rising at the shortest day he will be 40° from east towards the south, at midday he will be but 15° above the horizon, and the length of the day will be only seven hours and a half. At the vernal equinox, or 21st of March, the sun rises exactly east, is seen at the meridian 38½° above the horizon, and the length of the day is twelve hours. At the longest day, or 21st of June, the sun rises 40° from the east towards the north, at mid-day is 62° above the horizon, and the length of the day is sixteen hours and a half. These phenomena may be shown by rectifying the globe for the latitude, and bringing the sun's place for any given day to the meridian, and then setting the index to twelve, after which [illegible]

ing the sun's place to the horizon, noticing the point of the compass, time of rising, then to the meridian, and counting the degrees of elevation above the horizon, and afterwards bringing it round to the west.

By elevating the pole a number of degrees equal to those of the latitude of any other place, the same phenomena may be shown as they will appear at that place. It will be found that at places farther south than London the day is longer in winter, but shorter in summer, and that both in summer and winter the sun is higher above the horizon at twelve o'clock than he was at the same time at London. On the other hand, at places farther north than London, the day is shorter in winter, but longer in summer; and in summer and winter the sun does not rise so high above the horizon as at London.

In performing this problem it will be observed how small the arch is which is described by the sun at the shortest day, and how much it increases in proportion as the

sun rises further towards the north as the day becomes longer.

To impress these phenomena on the mind, let the pupil find the length of the day, the number of degrees from the east, either towards the north or towards the south of the point in the horizon where the sun rises, and the meridian altitude on January 1, April 1, July 1, and October 1, at Berghen, in latitude 60° 11′; at London, latitude 51½°, at Lisbon, latitude 38° 42′, and at Alexandria, latitude 30° 21′.

The apparent size of the sun is different at different times of the year, by which it is known that he is farther distant at one time than at another. Let us suppose the whole circle of the heavens divided into 360°, each of which may be subdivided into 60′, and each of these into 60″, &c. The apparent size of the sun's body, when greatest, is 32′ 37″ 30‴, and when smallest 31′ 32″ 30‴, which gives the mean apparent size 32′ 5″.

Any globe, when viewed at a little distance, will appear to the eye a circular plane, all difference of light and shade from

the presence or total absence of the parts being lost and imperceptible. Hence the sun, moon, and planets present to us the appearance of planes. A ball of iron heated red hot would, at a few yards distance, be exactly similar in appearance to a flat piece of iron.

The diameter of the sun being about 880,000 English miles, its bulk is nearly 1,400,000 times as great; but its density being estimated at only 1/4 that of water, while that of the earth is 5½ times water, the quantity of matter in the sun is not more than from 3 to 400,000 times that of the earth.

When the sun is seen through a telescope with the dark-colored eye to behold him, the eyepiece shaded off with, or a shade of smoked glass, it is found that the body does not present one uniform blaze of light, but that there are large spaces which are dark and from which no light proceeds. These are called the spots in the sun. These spots appear on the disk, gradually advance to occupy the middle of the body of the sun,

she rises farther towards the north as the day becomes longer.

To impress these phenomena on the mind, let the pupil find the length of the day, the number of degrees from the east, either towards the north or towards the south of the point in the horizon where the sun rises, and the meridian altitude on January 1, April 1, July 1, and October 1, at [illegible], in latitude 60° [illegible]'; at London, latitude 51½°; at Naples, latitude 40° 52'; and at Alexandria, latitude [illegible].

The apparent size of the sun is different at different times of the year, by which it is known that he is farther distant at one time than at another. Let us suppose the whole circle of the heavens divided into 360°, each of which may be subdivided into 60', and each of these into 60", &c. The apparent size of the solar body, when greatest, is 32' 35" [illegible], and when smallest 31' 31" [illegible], which gives the mean apparent size [illegible].

Any globe, when viewed at a little distance, will appear to the eye a circular plane, all gradations of light and shade [illegible]

the greater or less distance of the parts being lost and imperceptible. Hence the sun, moon, and planets present to us the appearance of planes. A ball of iron heated red hot would, at a few yards distance, be exactly similar in appearance to a flat piece of iron.

The diameter of the sun being about 880,000 English miles, his bulk is nearly 1,400,000 times as great; but his density being estimated at only $1\frac{2}{15}$ that of water, whilst that of the earth is $4\frac{1}{2}$ that of water, the quantity of matter in the sun is not more than from 3 to 400,000 times that of the earth.

When the sun is seen through a telescope which, to enable the eye to behold him, has a green shade of silk or a shade of smoked glass, it is found that his body does not present one uniform blaze of light, but that there are large spaces which are dark and from which no light proceeds. These are called the spots in the sun. These spots appear on one side, gradually come on to occupy the middle of the body of the sun,

and, after a time, disappear on the other side, and, after a certain number of days, re-appear. By this observation it is manifest that the sun has a revolution on his axis, and long and correct observation has determined this to take place in about twenty-five days and a half. The equator of the sun is found to incline about $7\frac{1}{2}°$ to the plane of the ecliptic, or the line of his course through the heavens. The solar spots are not perpetual, but are sometimes on one part and sometimes on another, and some years they are much more numerous than in others; yet some spots will continue for a long time, which enables astronomers to renew, when they please, their observations, to determine the period of his revolution on his axis. In general the spots are seen within 30° of the solar equator, but some have been seen as far as 44° from his equator.

After sun-set in the spring of the year there is often to be seen a phenomenon which has been termed the zodiacal light. It is of a white colour, like a pyramid in shape, of which the base is the sun and the top the

Immense Volcanic eruption
Mountains measuring through
the atmosphere of light -
Porous cavities
Lights floating about on the surfa

such, after a time, disappear on the other side; and, after a certain number of days, reappear. By such observations astronomers find that the sun has a revolution on his axis, and long and careful observation has determined this to take place in about twenty-five days and a half. The equator of the sun is found to incline about 7° to the plane of the ecliptic, or the line of his course through the heavens. The solar spots are not perpetual, but are sometimes on one part and sometimes on another, and some years they are much more numerous than in others; yet some spots will continue for a long time, which enables astronomers to notice, when they please, these observations to determine the period of his revolution on his axis. In general the spots are seen within 30° of the solar equator, but some have been seen as far as 40° from his equator.

After sunset in the spring of the year there is often to be seen a phenomenon which has been termed the zodiacal light. It is of a conic form, like a pyramid in shape, of which the base is the sun and the top [illegible]

than the outer circle – The effe...
a dense atmosphere –

zodiac. It was remarked in 1683 by Cassini. It is supposed to be the atmosphere of the sun. It is certainly very rare, as stars are easily seen through it. It sometimes inclines at an angle of 45° or even of 100° or 120°. The cause of this phenomenon is still in considerable obscurity.

Mathematicians have endeavoured to calculate the distance of the sun by the rules of plane trigonometry, the base being the radius of the earth, and the angle at the meridian and at the horizon being observed. It is unnecessary here to enter into a detail of the methods by which this is effected; the result is, that the distance of the sun from the earth has been found to be about 23,578 semi-diameters of the earth.

It has been a question of great importance in all ages, what was the nature of the sun's body, and what was the source of his light.

"Whence are thy beams, O sun! thy everlasting light?"

By some it was thought the sun was a body of fire, and that he gave out light and

heat in the progress of his conflagration. It is now more usual for Astronomers to suppose that the sun is encompassed with the matter of light, much in the same manner as our earth is by the atmosphere, and projects the light from him on surrounding space, whilst his own body may perhaps be an habitable world. The spots have been supposed to be parts of the body of the sun, but others have imagined them to be like clouds floating about him. It is impossible at present to decide, and therefore the most prudent part for the student is to suspend his judgment on this subject until further knowledge shall have been obtained respecting the real nature of light and heat; and, from the discoveries now constantly making, we may hope that something more permanent than theories hitherto received will soon be obtained.

The vast magnitude of the sun causes him to be the centre around which the earth and planets revolve. The SOLAR SYSTEM consists of the Sun, Mercury, Venus, the Earth, with her attendant the Moon, Mars,

Ceres, Pallas, Juno, Vesta, Jupiter, with his four moons, Saturn, with his seven moons, and, lastly, Herschel, with his six moons. Besides these we may [illegible], before entering upon an account of the laws by which these planetary bodies are regulated, their movements, [illegible] [illegible], [illegible] [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible].

Ceres, Pallas, Juno, Vesta, Jupiter, with his four moons, Saturn, with his seven moons, and, lastly, Herschel, with his six moons. Besides these are also the comets. Before entering upon an account of the laws by which all these planetary bodies are regulated in their revolution round the sun, we shall give a description of them one by one.

OF MERCURY.

THE planet Mercury, when seen a little before sun-rise, or a little after sun-set, is brilliant and sparkling like a diamond. From his vicinity to the sun the light which falls upon him must be intense, and consequently the light reflected from him may be expected to be vivid. It is but seldom that he is to be seen by the naked eye, only at such times as he is at his greatest distance from the sun, which never exceeds 29°. After he first begins to be distinguished in the evening immediately after sun-set, he recedes, by little and little, from the sun, proceeding then directly through the stars of the ecliptic, from west to east; but in a few days he is at his greatest elongation, when he sets, at the farthest, within an hour and fifty minutes after the sun; and then he gradually approaches the sun, and after a few days is lost in his light. After being many days invisible, in the morning he is

goes again before our day, and in a few successive mornings catches and carries, among then rise ... in ... when he rises, at the farthest, an hour and fifty minutes before the sun; but, having got to his greatest elongation, he again returns direct towards the east, and, in a few days, replunges into the light of the solar ray, which he becomes invisible to our eyes.

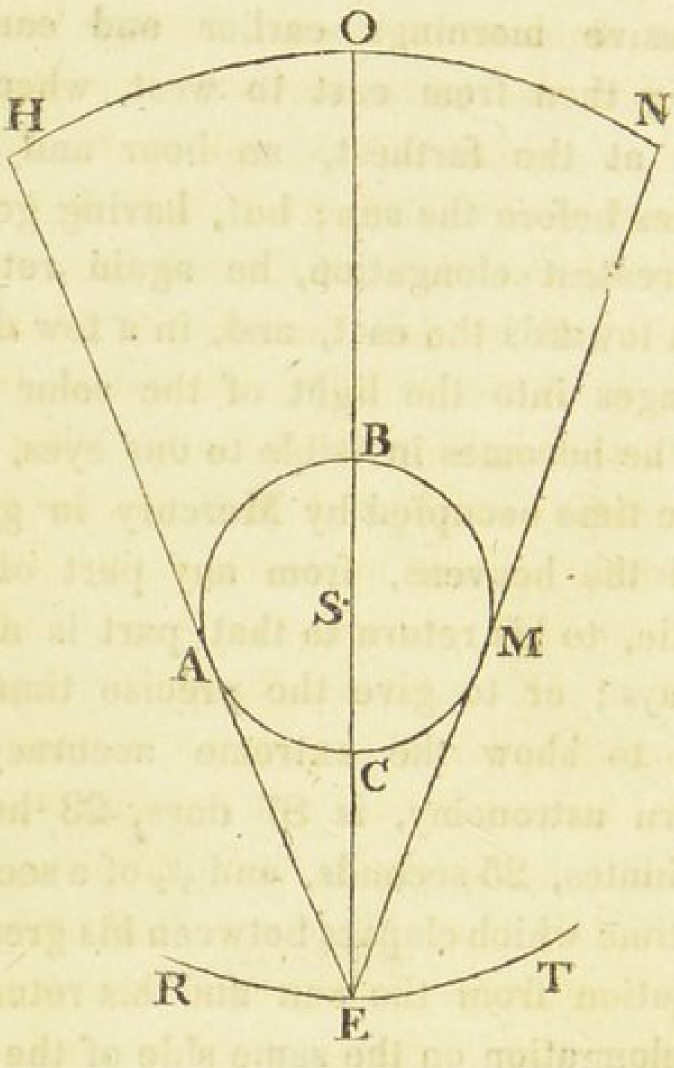
The time occupied by Mercury in going round the heavens, from any part of the ecliptic, to his return to that part is about 88 days; or to give the precise time, in order to show the extreme accuracy of modern astronomy, it 87 days, 23 hours, 14 minutes, 33 seconds, and [illegible] of a second. The time which elapses between his greatest elongation from the sun and his return to that elongation on the same side of the sun, whether as a morning or evening star, is about 116 days.

A reference to the diagram will explain the cause of Mercury appearing to be at one time direct and at another time retrograde in his motion.

seen again before sun-rise, and for a few successive mornings earlier and earlier, moving then from east to west, when he rises, at the farthest, an hour and fifty minutes before the sun; but, having got to his greatest elongation, he again returns direct towards the east, and, in a few days, replunges into the light of the solar ray, when he becomes invisible to our eyes.

The time occupied by Mercury in going round the heavens, from any part of the ecliptic, to his return to that part is about 88 days; or to give the precise time, in order to show the extreme accuracy of modern astronomy, is 87 days, 23 hours, 14 minutes, 25 seconds, and $\frac{9}{10}$ of a second. The time which elapses between his greatest elongation from the sun and his return to that elongation on the same side of the sun, whether as a morning or evening star, is about 116 days.

A reference to the diagram will explain the cause of Mercury appearing to be at one time direct and at another time retrograde in his motion.



Let S be the sun, A C M B the orbit of Mercury, R E T part of the orbit of the earth, H O N the distant firmament of stars. Let E be the earth's place, and M the place of Mercury at his greatest elongation from the sun. The observer at E will

refer him to the stars at N, and as Mercury moves much more quickly through the heavens than the earth we may consider the earth as remaining at rest at E, and as Mercury goes on his orbit M B A he will appear to pass through the heavens, so that when at B he will be referred to O, and when at A he will be referred to H, his greatest elongation on the other side. As he proceeds on through A C M, the rest of his orbit, he will appear to return, so that when at C he will appear to be at O, and when at M to be at N, during that time having an apparent retrograde motion. The earth, however, does not remain stationary at E but holds on in her orbit, but much less rapidly than Mercury; that planet will therefore have proceeded much farther through the heavens than H before he arrives at his greatest elongation, and will not return in his retrograde motion so far as N; and before his next direct motion through the heavens has brought him to his greatest elongation, he will be much farther

advanced than before, and his retrograde motion will not bring him so far back as at first.

When two heavenly bodies are seen near to each other they are said to be in conjunction. This may be the case with Mercury or Venus with the sun, either when in that part of their orbits which is between us and the sun, or on the other side. Two heavenly bodies are said to be in opposition when in opposite parts of the heavens. This can never be the case with Mercury or Venus with the sun, as neither planet is ever sufficiently remote from him.

Mercury, when viewed by telescopes of great power, appears to have phases like those of the moon, and his horns are directed towards the east when an evening star, and towards the west when a morning star.

Sometimes Mercury comes directly between our earth and the sun, and is then seen through a telescope like a very minute black spot, entering upon one side and gradually proceeding across the sun's disk to the other.

brilliant than at first, by the enlargement of the
disc, it not being lost in the rays, as at first.

When two heavenly bodies are seen near
to each other they are said to be in conjunc-
tion. This may be the case with Mercury
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[illegible] are said to be in opposition when
in opposite parts of the heavens. [illegible]
never be the case with Mercury or Venus
[illegible] the sun, as neither planet is ever
[illegible] so far from him.

Mercury, when seen with the telescope [illegible]
great power, appears to have phases like
those of the moon, and his horns are turned
towards the sun [illegible] like the moon.

Sometimes Mercury passes directly be-
tween our earth and the sun, and is then seen
through a telescope like a very minute black
spot, entering upon one side and gradually
proceeding across the sun's disk to the
other.

The ancients gave to this planet the name of the god Mercury. The figure by which he is marked in Almanacs is ☿, and which is intended to represent the caduceus or rod of Mercury, with two snakes twisting round it, which the ancient fables represent Mercury as carrying.

The path of Mercury through the heavens is not in the plane of the ecliptic, but inclined to it about 7°.

The mean apparent diameter of Mercury is about 10″, which, by a calculation of trigonometry, makes his diameter in English miles about 3224, which will give his bulk about $\frac{1}{15}$ that of the earth; but as his density is supposed to be $9\frac{1}{6}$ that of water, whilst that of the earth is only $4\frac{1}{2}$, the quantity of matter must be about $\frac{11}{81}$, or nearly $\frac{1}{7}$ that of our globe.

OF VENUS.

VENUS is the brightest and most beautiful of all the planets; of a white colour, a little inclined to yellow. She is mentioned in Homer's Iliad, xxii. line 338; also by Hesiod. This planet is also mentioned in Isaiah, xiv. The name of the goddess Venus has been bestowed upon it by the Greeks and Romans, as being supposed to be the favourite of that divinity.

> Qualis ubi Oceani perfusus Lucifer unda,
> Quem Venus ante alios astrorum diligit ignes.
>
> Æneid, viii. l. 589.

When this planet is first seen in the evening, it is a little after sun-set, and night after night, for some time, she holds on her way direct towards the east, and removing farther and farther from the sun. When arrived at her greatest elongation, she then again begins to approach the sun, and at last is lost in his light. After being for

[illegible]

some days invisible, this planet is again seen in the morning, a little before sun-rise, and is called the morning star; and she continues to advance in a retrogade motion amongst the stars, removing farther and farther from the sun, until she has again got to her greatest elongation, when she again commences a direct motion along the heavens, and approaching to the sun, at last becomes invisible in the blaze of his light, and until she again appear after sun-set as the evening star. The same cause which makes Mercury appear to have a retrogade motion, occasions the same in Venus also. The mean time occupied by Venus, from her greatest elongation in the evening to her return to the same position, is 584 days. She is therefore an evening star for more than nine months, and a morning star for about the same time. Venus takes up 224 days 16 hours 41 minutes $32\frac{4}{10}$ seconds in completing her revolution round the sun.

Venus reflects on the earth more light than what proceeds from any of the other

planets, or of the fixed stars; and indeed at times her light is superior to that of all the others put together, for she casts a shadow on the ground, which they do not. This shadow is distinctly perceptible on the grass or on a white wall.

When examined by the telescope, the phases of Venus are much more distinctly seen than those of Mercury; indeed almost as perceptible as those of the moon; her horns being pointed towards the east when an evening star, and towards the west when a morning star. When Venus presents her full enlightened face on the earth, she is then on the side of the sun farthest from the earth, and accordingly she then appears comparatively small, and her light is widely scattered before it reach the earth. She gives most light when she is so situated, that about little more than one quarter of the enlightened disk is seen from the earth.

The apparent diameter of Venus is, when in that part of her orbit nearest the earth, four times as much as it is when she is seen in the part of her orbit which is farthest off.

Venus is sometimes so bright as to be seen in full day by the naked eye. This phenomenon depends only on her relative position in regard to the sun, and occurs almost every nineteen months, but with remarkable splendour every eight years. Not being, however, generally noticed by the common people, when they happen to observe it they feel great surprise. In the time of Dr. Halley it occurred at London, and that astronomer had to explain the phenomenon, to remove the terror which was entertained of judgments coming on the country.

Venus sometimes passes directly between the earth and the sun, and she then appears like a spot on his disk. This is called the transit of Venus, and is of great importance to astronomers, as by observations then made they have been better able to determine the distance of the planets from the sun, and their proportional bulk. The two last transits were in 1761 and 1769. Astronomers observed them in every part of the world, where there were observatories, and ob-

servers were sent out to distant countries for the same purpose. Amongst others, the English government sent out astronomers to the south seas. The two next transits will be on the 8th of December, 1874, and 6th of December, 1882.

The path of Venus is inclined to the plane of the ecliptic 3° 24′.

From observation of some spots on her disk, it has been supposed, by Cassini, that Venus has a motion on her axis which takes place in about 23 hours 21 minutes, and that her equator forms a considerable angle with her ecliptic. Venus is also believed by him to have very high mountains, and to have an atmosphere of which the refractive power differs little from that of the earth. These phenomena are extremely difficult to be seen, even with the best telescopes, particularly in our climate; and it remains for future astronomers to confirm or refute them.

The symbol ♀, which was employed to represent Venus by the ancients, was the

figure of a silver looking-glass, with a handle to it; a suitable emblem for the goddess of love and beauty.

The mean apparent diameter of Venus is 58″, which by trigonometrical calculation will make the diameter about 7687 English miles. Hence the bulk of Venus is nearly the same as that of the earth; but, as the density is supposed to be greater about $5\frac{1}{15}$ than that of water, the quantity of matter will exceed a little the matter in the earth.

OF THE EARTH.

THAT the Earth is round like a ball seems at first to contradict the evidence of our senses, and it is certainly opposed to common prejudices; for though the earth may be proved to be round, yet it is a body of so large a size, that within the narrow space of what is at any one time submitted to our view, the obliquity is not very considerable or manifest. The globular figure of the earth was known to the ancients, and admitted by those who were not convinced of the earth's motion, or of there being antipodes, or inhabitants, on the opposite side. In the earlier periods of antiquity the globular figure was unknown, and one philosopher imagined he had explained how the earth was supported, by supposing it to be placed on the back of an elephant, and that elephant to be placed on the back of a tortoise. Herodotus, about 400 years A.C. sneers at the idea of the rotundity of the

earth, yet about that time this truth was well known to the Egyptians.

The arguments by which the earth's rotundity is proved are as follows:

1. When standing on an eminence, it appears to the eye that there is a bend in the horizon, and [illegible] we are surrounded, if we ascend a hill near the sea, for at every step the prospect is enlarged. The same is the case in ascending a tower, and objects which were not visible at the lower parts can then be distinctly seen. If the surface of the earth were flat, a person might be [illegible] as the distance [illegible] case. The [illegible] of the up-most were much [illegible] than the [illegible]. It is [illegible] the tower of a light-house, after [illegible] only that [illegible] may [illegible] be [illegible] after [illegible] it [illegible] may well be [illegible] a third time by going up to the [illegible].

2. If we observe a ship departing from the land, her hull first disappears, then her yards, and lastly even her topmasts. Now, when hull is the most bulky [illegible] would

earth, yet about that time this truth was well known to the Egyptians.

The arguments by which the earth's rotundity is proved are as follows:

1. If we stand by the sea-shore, it appears to the eye that there is a bend in the horizon; and of this we are convinced if we ascend a hill near the sea, for at every step our prospect is enlarged. The same is the case in ascending a tower, and vessels which were not visible at the water side may then be distinctly seen. If the surface of the sea were flat, a vessel might be seen at the same distance in either case. The sailor at the top-mast sees much farther than the sailors on deck. By ascending half way up the tower of a light-house, after seeing the sun set, that luminary may again be seen, and after he has a second time disappeared, he may still be seen set a third time by going up to the top.

2. If we observe a ship departing from the land, her hull first disappears, then her yards, and afterwards her top-mast. Now, as her hull is the most bulky part, this would

not be the first to disappear were the surface of the sea not curved. If we observe a ship come in sight, her top-mast is first seen, then the yards and sails, and lastly the hull. If various ships be in sight at the same time, the hulls of those which are near us are visible; of those at a greater distance we see no lower than the yards, and of those farther off only the top-masts.

3. It was at an early period observed by the ancient astronomers that, in going northwards, certain stars which were situated towards the south were not to be seen. Also, if they went southward nearer the equator, stars formerly not to be seen were then visible. If the earth had been a plain, the same stars would have been seen from every part of it; whereas, the whole stars in the heavens are not visible from any other place but from the equator. By rectifying the globe for the latitude of any place, and turning it round, it will be seen what stars never rise above the horizon at that place. At the poles only stars of one hemisphere are ever visible.

4. It was also observed, that the sun appeared at a different elevation at one place from what he did at another. At Alexandria at the longest day the sun would be 83° 7′ above the horizon at 12 o'clock, at Athens he would be only 75° 23′, and at Byzantium 72° 28′. This could arise from no other reason, but the rotundity of the shape of the earth. This different elevation of the sun was first noticed from the different length of the shadows. The elevation of the moon and stars was observed to be effected in a similar manner.

5. In an eclipse of the moon, which is caused by the earth coming between the sun and moon, the outline of the earth's shadow is always round, which would not always be the case if the earth were not round.

These reasons were sufficient to prove the rotundity to the ancients, and there are a variety of proofs known to us which confirm them.

6. As the figure of the sun, moon, and planets is ascertained to be globular, by

analogy, we ought to expect that of our earth to be so too.

7. In levelling to make a canal, it is found necessary to go seven or eight inches every mile below the straight line or level; if this were not done the line of the level would leave the earth altogether.

9. In addition to these, the earth has been circumnavigated times innumerable since the time of Magellan in 1519, by Drake, Anson, Cook, Bougainville, and innumerable other navigators.

It being ascertained that the earth is globular, it is next to be considered what is its size. This was attempted to be done by the ancients. Posidonius, who was coeval with Pompey and Cicero, observed that the star Canopus, in the constellation Argo, which at Alexandria was $7\frac{1}{2}°$ above the horizon, when at the meridian came only into the horizon at Rhodes. He thence inferred that the distance between the two places was $7\frac{1}{2}°$ or $\frac{1}{48}$ of the earth's circumference. It was only necessary then to ascertain the dis-

tance between these two, and to multiply by 48, to have the earth's circumference. He supposed the distance to be 3750 stadia, and hence reckoned the circumference to be 180,000 stadia. This is the size of the earth as given by Ptolemy in his geography. Eratosthenes, 194 A. C. by order of King Ptolemy, ascertained the latitude of Syene in Upper Egypt, and of Alexandria, and attempted to measure the earth. The Caleph Almamoun, about 800 A. D. attempted the problem in the same way, by causing the distance of two degrees to be measured in the plain Sinjar, near the Red Sea.

The principle upon which the ancients attempted this calculation was just, but they were very inaccurate in carrying it into execution. Rhodes is not $7\frac{1}{2}°$ north of Alexandria, being only about 5°, and the distance assigned, 3750 stadia, was a number taken at random. As we cannot be certain what was the exact length of the Grecian stadium, we are unable to ascertain the amount of the error. It is also unfortunate that the numbers vary in different authors.

In 1635 Norwood, an Englishman, attempted the solution of the problem, by measuring the distance from London to York, and by a mariners' compass taking the bearings of the road at every change of its direction, and by the usual rules in navigation, finding the distance in a straight line. The result found by this method was honourable from its accuracy to the mathematician, and gave $69\frac{1}{2}$ miles and 14 poles to a degree, which would make the circumference of the earth to be about 25,035 miles, which is a degree of accuracy highly astonishing, considering the state of science at the time.

Since his time various admeasurements have been made of parts of the earth's surface, from which the extent has been accurately ascertained. The French have, with extreme exactness, measured from Formentera, one of the Balearic islands, to Dunkirk; and a trigonometrical survey, conducted with at least equal skill and science, has been extended over Great Britain.

The French sent out mathematicians who measured a degree in Peru on the equator;

Temperature - affected by latitude - proximity near the sea - whether in old or new world - on the North side of the Equator -

and to Tornea to measure within the Arctic circle. Various other measurements have been made in North America, Africa, and India.

As the result of all these, it is ascertained the distance from the pole to the equator is about 32,808,990 feet, or about $6213\frac{8}{10}$ miles.

The whole circumference of the earth is therefore about 24,855 English miles, and the diameter about $7911\frac{6}{10}$ miles.

These admeasurements have ascertained another fact respecting the form of the earth, which was first suggested by Sir Isaac Newton. The earth in reality is not exactly globular, but flattened a little towards the poles; so that the diameter from pole to pole is to the diameter across the equator as 229 to 230. This swelling of the earth at the equator is occasioned by the motion of the earth on its axis, which tends to throw out bodies, by that tendency which matter has to fly off as far as possible from the centre of motion. If the earth were to revolve in twelve hours, instead of twenty-

...ngth of Pendulum at

0 . . . . .99669 metre

20° .99745

48.44 .99950

four, this enlargement at the equator would be much greater; and, were the earth to revolve in forty-eight hours, there would be less difference between the diameter from pole to pole and across at the equator. The matter accumulating at the equator increases there the power of attraction, and has at last sufficient power to check the influence of the centrifugal force, and consequently no greater enlargement after that takes place.

To find the Meridian.
Observe the Sun at equal heights
also stars — the exact line
between is the meridian

Light around the Polar
regions increased by the
Refraction which is greater
from the condensed air.
Reflection from the snow.
Long twilight

Moon appears larger at [illegible]
horizon - by appearing farther off
Look through a tube -
It appears further to the edge of the
horizon, than to the Zenith.

OF THE MOON AND HER MOTIONS.

It has been already shown that the moon has a diurnal motion similar to that of the sun, rising in the east, and describing an arc through the heavens and setting in the west. In the course of twenty-seven days, seven hours, and forty-three minutes, the moon makes a progress through the ecliptic and returns to the same stars, or in nearly fifty-five days goes twice round the heavens, and comes back to the same stars. When it is new moon she is between us and the sun, and is of course invisible, as the light which falls upon her is reflected back in the opposite direction. But two or three evenings after, as the moon comes round the heavens in twenty-seven days, seven hours, forty-three minutes, whereas the sun requires a year, the moon is so far distant from the sun, that she is visible after sun-set, and the light is then reflected from the crescent which is seen

Apparent diameter as
measured by the micrometer
greater or less according to the distance
Sometimes greater than the greatest

by us; the light from the remaining part of the illuminated face being reflected in another direction. Every succeeding night the moon is seen at a greater distance from the sun, and a larger part of her disk is visible. At last, in about a fortnight, the moon has got to that part of the heavens which is directly opposite to the sun, and the light from the full orb is reflected back to us, and it is then said to be full moon. The moon still continues her progress towards the east amongst the fixed stars, and approaches the sun on the other side, and the enlightened part of her disk as seen from the earth becomes less and less, and is in a different side from what it was with the first and second quarters of her course. The horns of the moon are always directed from the sun; hence her horns point towards the east after new moon, and she continues to fill up the vacant space till half moon; and, still increasing in the part visible from the earth, she is called gibbous until full moon. After that she begins to disappear in the west side, and is called gibbous until next

to us; the light from the remaining part of the illuminated face being reflected in another direction. Every succeeding night the moon is seen at a greater distance from the sun, and a larger part of her disk is visible. At last, in about a fortnight, the moon has got to that part of the heavens which is directly opposite to the sun, and the light from the full orb is reflected back to us, and it is then said to be full moon. The moon still continues her progress towards the east amongst the fixed stars, but she approaches the sun on the other side, and the enlightened part of her surface presented to the earth becomes less and less, and in a different situation from what it was with her first [illegible] quarter of her course. The horns of the moon are always directed from the sun; hence her horns point towards the east after full moon, and she continues to [illegible] the crescent again till half [illegible]. She [illegible] increasing, in the part which from the earth, she is called gibbous until full moon. When that she begins to disappear [illegible] decreasing, and is called gibbous until [illegible]

half moon, and for the remaining quarter her horns are directed towards the west.

As at full moon the sun and moon are in directly opposite parts of the heavens, it follows that, at twelve o'clock at night, the moon will be exactly south, or on the meridian, and at the greatest height above the horizon for that night. As the new moon is near the sun on the east side of him, she will appear after sun set, as soon as the diminished brightness of the light of day will allow her to be seen. After full moon the moon is to be looked for in the morning, and, as she rises later and later, in her last quarter she will rise but a little before the sun.

It is to be remarked, that in the first and second quarters that side of the moon which is towards the west is that which is illuminated, being that which is then next to the sun ; whereas in the third and last quarters, it is the side of the moon which is towards the east which is illuminated, and which is then next to the sun.

By observation it will be seen that the moon comes to the meridian every day about fifty minutes later than she did the day preceding.

The time the moon occupies in passing round the heavens from any star to her return to that star, is about twenty-seven days, seven hours, forty-three minutes; but the time which elapses from one new moon to another, is about twenty-nine days, twelve hours, forty-four minutes, two seconds. At new moon the sun and moon are in the same part of the heavens; but, by the time the moon has come back to that part, which is twenty-seven days, seven hours, forty-three minutes, the sun has proceeded on through the heavens 27° farther to the east, and is still going on, and the moon has to overtake him before she again be in that position which is called new moon.

The youthful student has no doubt remarked how little we see of the moon in summer, and how long and how clearly she shines in winter. As the moon when full is

in that part of the heavens which is opposite to the sun, and as the sun in summer is in that part of the ecliptic which makes long arcs above the horizon, the moon is in that part which makes but short arcs, continues but a little while above the horizon, and never rises very high. The full moon in summer revolves the same course which the sun does in winter. On the other hand, in winter the full moon is in the same place in the ecliptic which the sun occupies in summer, and performs a similar course, for exactly the same reasons. To impress this upon the mind, rectify for the latitude of the place ; and as the full moon about the longest day, 21st June, will be about the first of Capricorn, by turning the globe it will be seen what is the length of her course.

In the same manner find the full moon's place in the ecliptic at the shortest day, which will be about the beginning of Cancer, and turn the globe and observe the length of her course. As the moon's course is not exactly in the ecliptic, but comes 5° or 6° north or south of it, her time of continu-

ance above the horizon, and the brilliancy of her light will either be increased or diminished thereby as she is either nearer to us or farther from us than the ecliptic.

As in the northern climes of the world beyond a certain latitude there is a perpetual day in summer, so for the same reasons for a certain time every fortnight in winter the moon never sets, but continues the whole of the twenty-four hours to illuminate these snowy regions. This greatly softens the hardship of their condition; and when we consider that they have the reflection of this light from the snow, and that, in the absence of the moon, the stars and aurora borealis afford them light, they are not so much in darkness as we might suppose.

The moon in her monthly progress round the heavens uniformly presents the same face to the earth. In order to do this she must have a motion on her axis, and revolve round it, in exactly the same time which she takes to go round the heavens. We may be allowed to conjecture why nature has so disposed the moon to present uni-

[illegible] leaves are [illegible], and the [illegible] of [illegible] will [illegible] [illegible] [illegible] the [illegible] [illegible], as [illegible] is [illegible] [illegible] to [illegible] [illegible] than [illegible] the [illegible].

As in the northern regions of the world, [illegible] at certain latitudes there is a [illegible] day in summer, so for the same reason for a certain time every fortnight in winter the moon never sets. [illegible] the [illegible] of the [illegible] [illegible] the [illegible] regions. [illegible] the [illegible] of [illegible] [illegible] [illegible] the [illegible] that they have the [illegible] of [illegible] [illegible] the [illegible] that [illegible] the absence of the [illegible] [illegible] [illegible] as we [illegible] [illegible].

The moon in her monthly progress round the heavens constantly presents the same [illegible] to the earth. [illegible]

formly the same face to us, and we may suppose that the other side of the moon is less adapted for reflecting the light, and was intended by nature for another purpose. There is, however, what is called the libration of the moon, by which, in addition to the surface usually seen, a small space is noticed on her eastern and western side, and also a small space at her poles.

The half of the moon, which is next to the earth, enjoys either the direct light of the sun or the light reflected from the earth. The other half of the moon is a fortnight in the light and the next fortnight in darkness.

By accurate observation of the spots of the moon, Cassini was able to determine that the axis of the moon was precisely perpendicular to the ecliptic. The course of the moon through the heavens is not exactly in the ecliptic, or sun's path, for in that case, in the course of every month she would come between the earth and sun at new moon, and cause a solar eclipse, and at full moon the shadow of the earth would

fall upon her disk and cause a lunar eclipse. The moon's course, however, is never very far distant from the ecliptic, never exceeding from 5° to 6°, and half her course is on the south side and the other on the north. The points where the moon's course cuts the ecliptic are called nodes : that where she cuts the ecliptic in coming north being called the ascending node, and the other where she cuts the ecliptic going south the descending node. The place of the nodes is constantly varying, but according to a certain rule, so that astronomers can calculate it for a thousand years to come to the utmost precision of time. When the sun happens to be near the node at the time the moon passes it, there is an eclipse; or if the sun be directly opposite, on the other side of the heavens there is an eclipse.

The place of the nodes has a regressive motion of 19° 19′ 45″ in a year, which carries them round the ecliptic in 18 years 234 days. Hence after every nineteen years, the motion of the moon will be the same as before.

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[illegible]

This lunar cycle was inscribed by the Greeks in golden letters, and it was from that cause called the golden number.

The distance of the moon from the earth is about 240,000 miles or sixty semi-diameters of the earth. The diameter of the moon is about 2180 miles: the surface is $\frac{1}{13}$ and the bulk is $\frac{1}{48}$ that of the earth; but the quantity of matter is about $\frac{1}{40}$, the moon being more dense than the earth, being $5\frac{1}{2}$ that of water, whilst the density of the earth is $4\frac{1}{2}$.

The surface of the moon is very uneven. The brighter parts as seen to the eye are the tops of mountains, and the darker spots are supposed to be seas, in which the rays of the sun falling for the most part sink and are not reflected. The lunar mountains cast shadows on the plains, and these vary in appearance according as the moon is situated in regard to the sun. Many deep caverns are seen and on one side a shadow, and on the other is light, as we ought to expect. The surface of the moon, as seen through a telescope, resembles a honey-

comb. Mathematicians have attempted to measure the height of the lunar mountains, and have found them to be, in proportion to the comparative bulk of the earth and moon, much higher than those of the earth. There are appearances of volcanoes in the moon, and the formation of new spots and sparks observed in obscure parts lead us to believe that they are the eruptions of volcanoes in a state of activity.

It has been a matter much contested if the moon had any atmosphere at all. It is a well known principle in optics that light passing out of a rarer into a denser medium is subject to refraction. Hence the rays of the sun are bent on entering the region of the earth's atmosphere. Were the moon to have an atmosphere, as that of the earth, when she approaches near a star, in her progress through the heavens, the ray of light coming from the star to our earth would have to pass through the atmosphere of the moon, and the refraction would be visible, and easily ascertained by observation from the earth, for the star would not be so soon

more luminous towards the
der, than at the centre.

eclipsed by the moon, and would sooner come again into sight. Innumerable observations have given astronomers reason to suspect that there is a lunar atmosphere, but the effect produced by it is so small that the atmosphere must be of a rarity infinitely great compared with that of our earth, and, in fact, almost as rare as the vacuum produced in the air-pump. If the moon then be inhabited it must be by animals differently organised, as to breathing, from the animals on the surface of the earth.

It frequently happens, about three or four days after the new moon, that within the crescent appears the rest of the figure of the moon. This phenomenon is called by the French *lumiere cendrée.* It arises from the light which falls upon the earth being reflected upon the moon, and illuminating, to a certain degree, the face presented to the earth; the thin crescent reflects to us the full blaze of the solar light, and the rest of the lunar surface merely the comparatively feeble light from the earth.

It has been noticed that a brighter reflection proceeds from the moon when the continental parts of the earth are opposite to her, than when the great Atlantic or Pacific ocean is in the same situation. As there is less light reflected from the sea than from the land on the moon, it follows she cannot then return so much to us.

To the inhabitants of the moon the earth must present all the different phases or changes of appearance which the moon does to us; but as the earth's diameter is so much greater, it will appear about thirteen times larger. At the time when it is new moon to us, the earth being then on the opposite side from the sun, will reflect light from the whole of the surface, and will then be full to the moon. The opposite of this will be the case when it is full moon.

By observations on the earth the inhabitants of the moon may be able to obtain an annual division of time, from the alternate illumination and obscuration of the north and south pole.

OF THE MOON.

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To the inhabitants of the moon the earth must present all the different phases or changes of appearance which the moon does to us; but as the earth's diameter is so much greater, it will appear about thirteen times larger. At the time when it is new moon to us, the earth, being then on the opposite side from the sun, will be [illegible] to the people of the moon, and will appear to [illegible] a full moon. The opposite of this will be the case when it is full moon.

By observations on the earth, the inhabitants of the moon may be able to perceive [illegible] from the [illegible] [illegible] and [illegible] of the earth and [illegible].

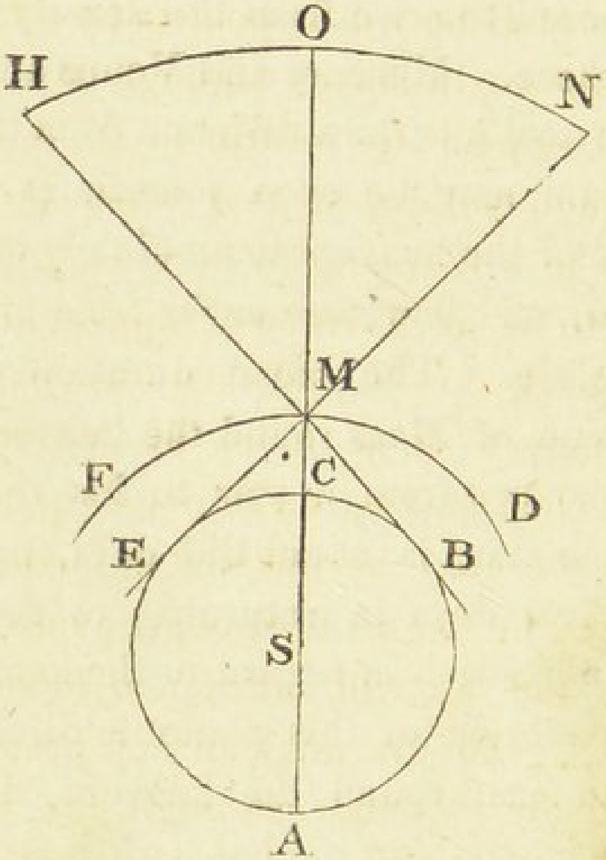
OF MARS.

THE planet Mars is less brilliant than Venus, and appears of a red colour, which is supposed to arise from the density of his atmosphere. Mercury and Venus are never seen beyond a certain distance from the sun, but Mars may be seen sometimes in the quarter of the heavens immediately opposite the sun, and therefore as far from him as it is possible. The mean duration of the revolution of Mars round the heaven, from his departure from a star to his return to the same star, is about 687 days, but he is about 780 days in returning to the same relative position in regard to the sun.

The motion of this planet is direct from west to east round the heavens, but not uniformly so, for he has, after a certain length of time, a retrograde motion for 16 degrees, occupying the time of 63 days. His course through the heavens is not exactly in the plane of the ecliptic, or the path

of the sun, but not far from it, being inclined only 1° 51′.

The cause of the apparent retrograde motion of Mars will appear from the following diagram and explanation.



Let S be the sun, and A B C E the orbit of the earth, D M F part of the orbit of Mars, and H O N the firmament of fixed stars. Let E be the earth's place, and as

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Let S be the sun, and A B L C R the orbit of the earth, D M F part of the orbit of Mars, and M O N the firmament of fixed stars. Let E be the earth's place, and [illegible]

Mars moves much less rapidly, he may be considered at rest. Whilst the earth moves through part of her orbit E A B he will appear to move from N to H, directly through the heavens ; so that when the earth is at A he will appear to be at O, and when the earth is at B he will appear to be at H; but whilst the earth moves through B C E to E he will appear to return to N, having a retrograde motion, so that when the earth is at C he will appear to be at O, and when the earth is at E he will appear to have come back to N. Whilst, however, the earth moves from E to B Mars is not at rest, but moving on through the heavens he will therefore be advanced farther than H before he begins to appear to move backwards, and he will not appear to return so far as N. In his next direct progress he will advance farther through the heavens than before, and will not return so far. Thus he will go on, making uniformly a long direct course and, alternately, a short retrograde course in the heavens.

Mars can be in conjunction with the sun

only when in the opposite part of his orbit to our earth, or on the other side of the sun. When he is in opposition to the sun the earth is between him and the sun, and as he is then nearest to the earth he will appear then to have a larger diameter, and give more light than at any other time.

Mars varies much in the length of his apparent diameter. At a mean distance it is 19″, but when he is in exact opposition to the sun, and nearest to the earth, the apparent diameter is 56″.

The disk of Mars, when examined through a telescope, has a different appearance at different times, according to his position in regard to the sun. He is never horned, like the moon, but is sometimes oval.

From spots on his surface it has been ascertained that he has a revolution on his axis in about 24 hours 39 minutes, and that his axis inclines to the plane of the ecliptic 60°. From the motion on his axis his equatorial diameter is longer than his diameter rom pole to pole in the proportion of 194 to 189.

Mars is not known to have any satellite or moon. He is indeed so small that were he to have a satellite it must be too minute to be perceived from our earth.

The symbol employed to represent Mars in our almanacs is ♂, of which the circular part is the shield, and the other part is the spear or arrow of a warrior, and were proper emblems for a planet on which was bestowed the name of the god of war.

The mean apparent diameter of Mars being 27″ his diameter in English miles is about 4190, his surface about $\frac{1}{4}$, and his bulk about $\frac{1}{7}$ that of the earth; but as his density is estimated to be only $3\frac{2}{7}$ that of water, the quantity of matter is only about $\frac{1}{10}$.

OF CERES, PALLAS, JUNO, AND VESTA.

THE success of Herschel in discovering a new planet, and the fame and immortality thereby acquired, induced many astronomers to explore the heavens with greater attention. The result has been the discovery of four planetary bodies, extremely minute in size, between the orbits of Mars and Jupiter, moving from west to east, like the other planetary bodies, and at times exhibiting the same phenomenon of an apparent retrograde motion.

Ceres was discovered by Piozzi, at Palermo, June 1, 1801; Pallas was discovered, March 21, 1802, by Olbers, of Bremen; Juno, September 1, 1804, by Harding; Vesta, March 29, 1807, by Olbers.

The orbit of Vesta is inclined to the ecliptic about 7°, that of Juno about 13°, of Ceres about 16°, and that of Pallas not less than about 35°.

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The orbit of Vesta is inclined to the ecliptic about 7°; that of Juno about 13°; of Ceres about 10°; and that of Pallas no less than about 35°.

Vesta revolves in	1326, 930 days.
Juno	1594, 23
Ceres	1681, 37
Pallas	1685, 619

These bodies are to be seen only by the help of very powerful telescopes, and they are extremely minute in size, the diameters being less than 200 English miles.

Mr. Olbers is of opinion that these planets are the fragments of one large planet, which an explosion, from some unknown cause, has burst in pieces; and hence he concludes that all their orbits ought to cut one another in two opposite points of the heavens, which he found by calculation to be one near the constellation Virgo, and the other near the whale, and that of course they must pass through these points in every revolution. In fact, the four have been found near these points, and the two last after Olbers had suggested this idea.

OF JUPITER.

JUPITER is next to Venus the most brilliant of the planets, and his colour is very white. His direct course is near the ecliptic, and not departing farther from it than 1° 19′, and may be traced from year to year, and it is 12 years before it is accomplished. If therefore he is seen near any star this year, by the same time next year he will have gone no farther to the east than the moon would have done in two days and a half. The same cause which makes Mars appear to have at times a retrograde motion will cause Jupiter to appear to have a retrograde motion also, but as he is at a great distance from the earth, the effect of the different situation of the earth in regard to him is not very considerable. Jupiter in his apparent retrograde motion passes over only ten degrees, but occupies above 121 days.

His revolution round the heavens is effected in about 4332 days, 14 hours. From his great distance the apparent diameter of Jupiter does not vary much in extent. Its mean is 36″ and when it is greatest it is 45″. When this planet appears brightest to us, he is more brilliant than when Venus is in the less bright parts of her course; but when Venus is in the brightest part of her course she much surpasses Jupiter.

From the spots on his surface he is known to revolve round an axis perpendicular to the ecliptic, from west to east in about 9 hours, 56 minutes. From this rapid revolution it necessarily arises, that there should be a considerable difference between his polar and equatorial diameters, and accordingly the former is to the latter as 167 to 177.

By calculating his distance, and observing the apparent diameter of this planet, he is known to be more than a thousand times larger than our earth.

There are seen on Jupiter what are called

belts, from their going round him. Tehy are parallel to each other, but they vary in their appearance from time to time, which gives reason to believe that they do not adhere to the body of the planet itself, but are floating around him like clouds in the atmosphere.

By observation of Jupiter with the telescope, there have been seen four satellites which revolve round him at different times, according as they are near to him or farther off: the nearest satellite occupying about 1 day 18 hours; the second about 3½ days; the third about 7 days, 4 hours; and the fourth about 16 days, 16 hours.

These satellites are sometimes seen to pass over the disk of Jupiter, and then they project a shadow on him. They are opaque and then shine only by reflecting the solar light. By passing between Jupiter and the sun they occasion eclipses of the sun to that planet, in the same manner as the moon occasions an eclipse of the sun to our Earth.

Jupiter casts a shadow behind him, and when his satellites pass through it, they are eclipsed in the same manner as our moon is by passing through the shadow of the earth. The satellites of Jupiter always disappear behind him, on that part which is opposite to the sun, and, of course, they then pass through his shadow. The motion of the satellites is from west to east.

As these satellites are at such a vast distance from our earth, their apparent diameter is altogether insensible; and as their appearance varies at different times, and according to the state of the atmosphere and the telescopes employed, and from other circumstances, it is impossible to determine, with any certainty, what is their size.

Their great proximity to Jupiter, is the cause of their rapid revolution around him. They have a mutual influence upon one another, which affects the regularity of their motions.

Assuming the apparent semi-diameter of Jupiter as unity, the following is the propor-

tional distance of his four satellites, and the times of their revolution, in days and fractional parts.

	Mean Distance.	Time of Revolution.
I. Satellite	6,04853	1,769137788148
II. Satellite	9,62347	3,551181017849
III. Satellite	15,35024	7,154552783970
IV. Satellite	26,99835	16,688769707084

The orbits of the first and second satellite differ so little from circles, that the elliptical form is imperceptible. In the orbit of the third satellite it is scarcely sensible; but in the fourth it may easily be perceived.

The satellites of Jupiter exemplify the proposition discovered by Kepler, that the squares of the times of revolving bodies are in proportion to the cubes of the distances.

The symbol for Jupiter ♃ is generally understood to be the letter Z, the first letter of Zeus, the name of Jupiter in Greek. It has also been thought to represent the forked lightning, and the fancied

mean distance of his four satellites, and the times of their revolution in days and decimal parts.

	Mean Distance.	Sidereal Revolution.
I. Satellite	6,04853	1,769137788148
II. Satellite	9,62347	3,551181017849
III. Satellite	15,35024	7,154552783970
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The satellites of Jupiter exemplify the proportions discovered by Kepler, that the squares of the times of revolving bodies are in proportion to the cubes of the distances.

The symbol for Jupiter ♃ is generally understood to be the letter Z, the first letter of Zeus, the name of Jupiter in Greek. It has also been thought to represent the forked lightning, and the thunder-

shape of the thunderbolts, which the god Jupiter was supposed to wield.

The diameter of Jupiter being about 90,000 English miles, his bulk is 1400 times that of the earth; but, as his density is estimated at only $1\frac{1}{24}$ that of water, the quantity of matter will be only about 324 times that of the earth.

OF SATURN.

SATURN is more remote from our earth than Jupiter, and he is of a somewhat livid colour, and less in appearance than Mars. His motion round the heavens is from west to east, almost in the plane of the ecliptic, not departing from it more than 2° 30′, and occupies a period of 10,759 days, or nearly 30 years. If, therefore, he be once recognized in the heavens near any large star, he will be found from year to year, making but a very small progress, not moving so much from that star in a year as the moon would in the course of 24 hours. In his apparent retrograde motion, he passes over very little more than 6 degrees in the space of 139 days. His mean apparent diameter is about 16″, but his size is not greatly affected by his position with regard to the earth and sun, his distance at all times being very considerable; for when nearest to the earth he is

distant more than eight times the distance of the earth from the sun, and when farthest from the earth only about ten times.

The proportion of the polar to the equatorial diameter of Saturn is nearly as 10 to 11. This indicates that this planet must revolve rapidly on his axis. Dr. Herschel, by diligent observation of this planet, with a powerful telescope, has ascertained that Saturn has a motion on his axis like all the planetary motions from west to east, and that the time of his diurnal motion is about 10 hours 16 minutes, being a little more than the time of Jupiter's diurnal rotation.

Saturn has seven satellites at various distances, and consequently revolving round him at various periods. By spots remarked on one of these satellites, it is ascertained that in revolving round Saturn, the same face is always presented to the primary planet, and it must therefore turn on its own axis in precisely the same time that it occupies in its orbit. In this respect it exactly resembles our moon and the satellites of

Jupiter, and it is probably a general rule of nature in regard to all secondary planets. We may conjecture, therefore, with seemingly good reason, that nature which is uniformly found to be economical in the means employed to effect her infinitely varied purposes, has formed one side of these secondaries better adapted than the other to reflect the light on their primaries, and that the two hemispheres of the secondaries vary in their nature and in the intention for which they were formed.

Assuming the apparent semi-diameter of Saturn as unity, the following will be the proportional distances of the satellites, with their times of revolution, in days and decimal parts of a day.

	Mean Distance.	Time of Revolution.
I. Satellite	3,351	0,94271
II. Satellite	4,300	1,37024
III. Satellite	5,284	1,88780
IV. Satellite	6,819	2,73948
V. Satellite	9,529	4,51749
VI. Satellite	22,081	15,94530
VII. Satellite	64,359	79,32960

The square of the times of revolution are to each other in proportion to the cubes of the distances.

From the vast distance of Saturn it is not easy to discover the elliptical form of the orbits of his satellites; that of his sixth satellite however is sensible.

Dr. Herschel observed on this planet five belts nearly parallel to his equator.

Saturn, when viewed through the telescope, presents to the astronomer a singular phenomenon of the appearance of a ring surrounding him. Huyghens, by long observation, ascertained that the ring was in all its parts detached from the body of the planet. This ring is inclined about 28° to the plane of the ecliptic, and is always presented obliquely to the earth, so as to have the appearance of an ellipse of which the breadth is about one half the length. It is sufficiently opaque to cast a shadow on the body of the planet, which is visible to some powerful telescopes. The position of the ring, in regard to the earth and sun, is frequently such as to render it invisible, as

its edge reflects little or no light. It has been perceived that the ring is double, or consisting of two rings one within the other, and that they revolve from west to east in about a very little more time than the planet itself, viz. in about 10 hours 29 minutes. Through the space between the planet and his ring the fixed stars may sometimes be seen. The symbol for Saturn ♄ is the figure of a sickle, the god Saturn, after whom this planet was named, having been in his life-time, when a king in Italy, a great agriculturist, and inventor of many useful instruments.

The diameter of Saturn being ten times as great as that of the earth, 79,000 miles, his bulk is 1000 times as great; but as his density is estimated to be only $\frac{13}{32}$ that of water, the quantity of matter will be about only 90 times that of the earth.

OF HERSCHEL.

THIS planet was discovered in 1781 by Dr. Herschel, who called it Georgium Sidus, in compliment to the king; but most astronomers have considered himself as better entitled to the honour; though some have named this planet Uranus. Flamstead, Mayer, and Le Monnier had long ago observed it as a little star; but in 1781, Dr. Herschel observed that it had shifted its place, and by continuing to observe it he found it to be a planet. The motion of Herschel from west to east is almost in the plane of the ecliptic, being inclined only 0° 46′, and to complete his revolution round the heavens would occupy 30,689 days, or about 84 years. For the same reason as with Mars, Jupiter, and Saturn, there is an apparent retrograde motion, which occupies 151 days, but such is his distance, that the number of degrees which he appears to go back does not exceed from 3 to 4.

Dr. Herschel discovered that this planet had six satellites revolving round it, but other astronomers have not been able to perceive so many.

The apparent diameter of Herschel hardly exceeds 4″.

Assuming this diameter as unity, the apparent distances of the six satellites, and the times of their revolution in days and decimal parts will be as follows.

	Mean Distance.	Time of Revolution.
I. Satellite	13,120	5,8926
II. Satellite	17,022	8,7068
III. Satellite	19,845	10,9611
IV. Satellite	22,752	13,4559
V. Satellite	45,507	38,0750
VI. Satellite	91,008	107,6944

The times of revolution of the second and fourth have been determined from observation. The times of revolution of the others have been calculated from their distance from the planet, by Kepler's rule of the squares of the times being in proportion to the cubes of the distances.

The symbol for Herschel ♅ is the first

letter of the name of the great discoverer, with a cross subjoined to it, as it was discovered in the time of Christianity.

The diameter of Herschel is about 35,000 English miles, his bulk is therefore about 83 times that of the earth; but his density being estimated at $\frac{22}{100}$ that of water the quantity of matter is only 18 times that of the earth.

The following are the places of the planets on the 1st of January, 1820.

	Longitude.	Latitude.	
Mercury . .	♏ 22° 12′	3° 5′	north
Venus . .	♑ 0° 30′	1° 31′	south
Mars . . .	♋ 1° 37′	3° 56′	north
Jupiter . .	♑ 18° 26′	6° 50′	south
Saturn . .	♒ 25° 1′	2° 16′	south
Herschel . .	♏ 25° 35′	0° 9′	south

Mercury and Venus rapidly change their place, Mars much more slowly, but the other three make comparatively a very small change of place in a long space of time. By means of an ephemeris, which is published every year, the place of the moon and planets for any given day may be found.

OF THE MOTION OF THE EARTH AND PLANETS ROUND THE SUN.

It was in the dark ages of the world supposed that the earth was the centre of the universe, and that not only did the heavens revolve round it in 24 hours, but also that the sun and planets had another motion round it; the sun in a year, the planets in different periods according to their distances. This ignorant theory was supported and attempted to be explained by Ptolemy, and it has hence been called the Ptolemaic system.

Observation on the motion of the planets proved that the phenomena presented could arise from no other cause whatever, but from the planets revolving round the sun. This theory Pythagoras learned in Egypt, and taught to his disciples; but as he did not make himself sufficiently acquainted with the proofs by which it was supported, it of course was received only by those

whose reverence for his authority was so great, as to induce them to depart from the commonly received opinions, and implicitly adopt whatever he taught.

The revival of science in modern times again re-established the belief of the Pythagorean system. It, however, revolted so much against the received prejudices of mankind, that even the learned and diligent astronomer Tycho Brahe, whilst he was compelled to acknowledge that the planets revolved round the sun, could not bring himself to believe that the earth was not the centre of the universe, and that the sun was not made to revolve round it.

His system was at once contradictory to itself and to all observed phenomena, and was obscure and complex, in every way opposed to the plans of nature, which are simple and uniform. It was impossible it could withstand the light of science; and the true system revived by Copernicus, whose name it has since borne, soon came into general belief. Such were the prejudices of the times, that attempting to oppose the

common errors was highly dangerous. Copernicus lived to see the proof of the last sheet of his work the day before his death, and ordered it to be published, being then beyond the reach of the Inquisition.

The observations of Tycho Brahe, notwithstanding the errors of his theory of the motions of the heavenly bodies, were extremely important. He had employed himself for nearly a score of years in observing the latitude and longitude of the fixed stars, of which he made a catalogue, and also the motions and phenomena of the other heavenly bodies. Kepler, his friend and the companion of his studies, by the help of Tycho's observations, together with his own, discovered a law of the planetary motions, which has been extremely useful, namely, that the square of the time which any planet occupies in its revolution round the sun is to the cube of the distance from the sun as the square of the time any other planet occupies to the cube of its distance.

The discovery, or rather the improvement of the telescope by Galileo, enabled astro-

nomers to make more accurate observations. The phases of the planets, the satellites of Jupiter and Saturn, with their motions, were interesting discoveries in themselves, and useful, as furnishing the means of developing the principles of the laws observed by nature, in guiding the movements of the different bodies in the universe.

This was reserved for the genius of Newton to explain to the world. It was he who discovered that the principle of attraction, which causes a stone to fall to the ground, extends universally throughout nature, and that by it the planets are attracted towards the sun. He found that attraction diminished in proportion to the square of the distance; so that at double the distance it will only be one-fourth so great; at three times the distance one-ninth as much; and so on. This force has been called the centripetal force, or force drawing towards the centre.

It is evident, that if there were no other force acting upon the planets they would soon be drawn down with accelerated velocity to the sun. But there is another force

which counteracts this, called the centrifugal force, which tends to carry a planet off. This force is the same which causes a stone in a sling, when thrown round the head, to fly off as far as possible, and when it leaves the sling carries it off in a line, a tangent to the circle which it made round the head. The same force acts in the case of a planet, and the effect of the two is that a planet neither is drawn towards the sun, nor yet flies off, but moves in an orbit between the two.

The two forces, in causing a planet to move in its orbit, must be equally balanced, otherwise it would either be brought constantly nearer to the sun, or would fly off into infinite space. As the attraction of the sun upon Mercury must be much greater than upon our earth, the centrifugal force must be much greater also. The consequence is, that Mercury must move much more rapidly forward in his orbit; and, as he has not only a much shorter orbit, but also moves at a quicker rate, the time he occupies in his revolution round the sun is

the planets observe in their revolution round the sun. The same rule holds in regard to the satellites of Saturn and Herschel.

Our moon moves more rapidly in that part of her orbit which is nearer the earth than when more remote. The satellites of the other planets observe the same rule.

The axis of the earth is not perpendicular to the plane of the ecliptic, but inclined to it 66° 32′ 3″, the obliquity of the ecliptic being 23° 27′ 57″, which is the cause of the diversity of seasons. During the whole period of the revolution round the sun the axis of the earth continues parallel to itself.

The orbits of the planets are not exactly circles, but ellipses, not much differing from circles. The sun is in one focus of the ellipse. Hence, in one part of the orbit the sun must be farther distant than in another; and, accordingly, the sun appears to us of a larger diameter at one time than another, which would not be the case if the earth's orbit was a circle, of which he occupied the centre. In like manner also the

moon appears of a larger diameter at one time than another.

When a planet is in that part of its orbit which is farthest from the sun there is less force of attraction, and, consequently, the motion is slower. It has been proved by mathematicians that the planets describe equal spaces in equal times; that is to say, supposing a string from the sun to a planet, that string would be drawn over an equal space in a day, whether the planet was distant or nearer the sun, for, when nearer the sun, the planet would move exactly so much faster as to compensate for the shorter length of the string.

As the earth is farther from the sun in our summer than in our winter months, in consequence, the motion is slower, and there is more time occupied in passing from the vernal to the autumnal equinox than in passing from the autumnal to the vernal equinox; the sun occupying 186 days, 11 hours, 51 minutes from the time he enters Aries till he enters Libra, and only 178

days, 17 hours, 58 minutes from entering Libra till he comes to Aries, the difference being 7 days, 17 hours, 53 minutes which our summer exceeds our winter. The heat of our summer is produced by the sun's rays descending upon us in a more perpendicular direction; for instance, at London, on the longest day, they form an angle with the horizon of about 62°, whilst at the shortest day of only 15°. The little difference produced by the sun being in our summer a little farther off is nothing in comparison of the effect produced from this circumstance.

To determine the precise distances of the planets from the sun is a most difficult problem in astronomy; and, from the imperfection of our senses and instruments, can never be done beyond a certain degree of accuracy, and to give the distances so exactly as to descend to hundreds, tens, and units is mere affectation. The times of revolution may be observed exactly, to less than a second.

days, 20 hours, 35 minutes: from hence till he comes to Aries, the difference being 7 days, 17 hours, 53 minutes which our summer exceeds our winter. The heat of our summer is produced by the sun's rays descending upon us in a more perpendicular direction: for instance, at London, on the longest day, they form an angle with the horizon of about 62°, whilst at the shortest day of only 15°. The little difference produced by the sun being in our summer a little farther off is nothing in comparison of the effect produced from this circumstance.

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The distances and times of revolution of the seven large planets of our solar system are as follows.

	Distance.	Time of Revolution.
☿ Mercury..	37,000,000	87 d. 23 h. 14 m. 25 s. $\frac{1}{10}$
♀ Venus....	68,000,000	224 d. 16 h. 41 m. 32 s. $\frac{4}{10}$
⊖ The Earth	96,000,000	365 d. 5 h. 48 m. 45½ s.
♂ Mars	145,000,000	68 days.
♃ Jupiter ..	490,000,000	4332 days 14 hours.
♄ Saturn....	900,000,000	10759 days.
♅ Herschel..	1800,000,000	30689 days.

Of these the earth has one satellite, Jupiter has four, Saturn has seven, and Herschel six.

The four minute bodies called Asteroids, Ceres, Pallas, Juno, and Vesta lie between the orbits of Mars and Jupiter.

OF ECLIPSES.

An eclipse of the sun is occasioned by the moon, in her progress through the heavens, intervening between the sun and the earth. Were the moon to move exactly in the plane of the ecliptic there would be an eclipse of the sun every month; but at new moon she generally either passes above or below the sun, and it is only when her node happens to cut the ecliptic within 64′ of the sun that there can be an eclipse, and it is only when the node cuts the ecliptic exactly where the centre of the sun is that there can be a total eclipse.

Eclipses are either TOTAL, ANNULAR, or PARTIAL.

In the case of TOTAL ECLIPSES the whole disk of the sun is hidden from our view. Such an eclipse is comparatively of rare occurrence. In ancient histories they have been recorded as events of an extraordinary nature; for instance, one occurred

illuminates more than the
half of it.

at the time of the death of Romulus, when he was in torn in pieces by the senators, and was supposed by the populace to have been carried up to heaven. A similar eclipse happened in the sixth year of the war between the Medes and the Lydians.

A large portion of the sun's disk may be eclipsed, and there may yet be sufficient light to render every thing visible. At Paris, in 1706, 10 digits, 58 minutes were eclipsed, and still there was abundance of light, although only one-eleventh part of the sun's disk remained to give light.* In 1699, on September 23, about an hundred and eighteenth part of the sun remained visible, and there was not light enough to enable people to read and write, and the stars were visible.

A total eclipse seldom lasts above 2 or 3 minutes, when the sun returns with all his

* As only about $\frac{1}{8}$ of the sun's disk will remain visible on September 7, 1820, the observer will have an opportunity of judging for himself of the effect of the diminution of light.

brilliancy. Clavius saw such an eclipse at Coimbra, August 21, 1560. It was dark as night, and indeed appeared darker. Birds fell to the ground.

From 1704 to 1900 the number of visible eclipses at Paris is 59, without one of all these being total.

An ANNULAR ECLIPSE is extremely beautiful, and occurs when the whole figure of the moon comes directly between the earth and sun, being at the time of an apparent smaller diameter than the sun. There is still a ring of light shining bright all round the dark figure in the middle. There was an annular eclipse seen at Cadiz in 1764, and there will be an annular eclipse at Paris on October 9, 1847.

A total or annular eclipse of the sun is, at its commencement, only a partial eclipse. As the cause of all eclipses is the moon's moving more rapidly from west to east through the heavens than the sun, and overtaking him, it must be that her eastern limb, which moves first, must first intervene between the earth and sun, and the western

side of the sun must be first hid from our view, and as the moon passes along his disk, it must first emerge into sight.

A PARTIAL ECLIPSE occurs when the new moon passes the sun, either so high up or so low as only to come between us and a part of his disk.

In giving an account of eclipses, the disk or face of the sun or moon is supposed to be divided into 12 parts or digits, and each digit into 60 minutes. The eclipse of the sun, September 7, 1820, is said to have 10 digits 27½ minutes eclipsed, which is about ⅞ of the disk of the sun. The eclipse of the moon on March 29, 1820, is said to have 6 digits 12 minutes eclipsed, which is about one half of her disk.

An eclipse of the sun may be visible or invisible at any given place. It is of course invisible at any given place if it be at a time either before sun-rise or after sun-set. But it may also be invisible even should it occur at 12 o'clock in the day, for the moon's shadow is not so extensive as to cover more than a small portion of the

earth's surface; so that when a total eclipse takes place at one place, it cannot extend over a greater diameter than 180 miles; and beyond that space a part of the sun's face may still be seen, when it is only a partial eclipse; and beyond that space the whole face of the sun may be visible; when it is there no eclipse at all, and the eclipse is therefore said to be invisible at that place.

The following notice is given in the Nautical Almanac for 1820, of an eclipse of the sun, visible at Greenwich, September 7th, of that year:

	Hours.	Minutes.
Beginning	0 :	24¼
Visible conjunction . . .	1 :	50¼
Greatest obscuration . .	1 :	53
End of the eclipse. . . .	3 :	16¾

Digits eclipsed: 10 digits 27½ minutes, sun's north limb.

There will therefore be ⅞ of the sun's disk eclipsed; and as the eclipse takes place so soon after 12 o'clock, the altitude of the sun is favourable for viewing it. A

piece of glass smoked over the candle is useful in protecting the eyes from the solar light.

The sun being so much larger than the earth or moon, their shadows must be in the form of a cone. The length of the cone of the shadow of the earth is about $3\frac{1}{2}$ times as long as the distance of the moon from the earth, and its breadth where it is traversed by the moon's is $2\frac{2}{3}$ the diameter of the moon.

An eclipse of the moon arises from the shadow of the earth falling on the moon. It must, therefore, only take place when the moon is on the side of the earth farthest from the sun, or at full moon. As it arises from the moon, in her progress through the heavens, coming within the earth's shadow, it must begin on that part of the moon which moves first, or her eastern side, and proceed across her disk; and her eastern side must first emerge from the darkness. An eclipse of the moon may be either partial or total. When a total eclipse takes place, it is of course only partial at first; and

after the moon begins to emerge from the shadow, it is then only partial, as more and more of her disk becomes visible, until at last her whole disk is again restored to view.

Eclipses of the moon, though of rarer occurrence than eclipses of the sun, are yet far more frequently visible at any given place. As the eclipse arises from the earth preventing the solar light from falling on the moon, that part of the moon which is obscured cannot emit light to any part of the earth whatever, and therefore the eclipse must be visible to the whole hemisphere of the earth which is opposite to the moon at the time, and to which the moon is visible.

To find, therefore, at what places of the earth any eclipse of the moon will be visible, it is only necessary to find at what part of the earth the sun at the time of the eclipse is vertical, and bring it to the meridian, and throughout the opposite hemisphere the lunar eclipse will be visible.

The following notice is given in the Nautical Almanac for 1820, of an eclipse of the moon, on March 29th, of that year:

	Hours.	Minutes.
Beginning of the eclipse.	5 :	$16\frac{5}{6}$
Moon rises eclipsed . . .	6 :	17
Middle of the eclipse . .	6 :	$37\frac{9}{10}$
Ecliptic opposition. . . .	6 :	$46\frac{1}{4}$
End of the eclipse. . . .	7 :	$58\frac{9}{10}$

Digits eclipsed: 6 digits 12 minutes, from the south side of the earth's shadow, or on the moon's north limb.

Eclipses, having made great impression on the ancient nations, are often recorded in history. As astronomers can easily calculate backwards and find the precise year, day, hour, minute, and second when any eclipse took place, many dates in ancient history may thereby be ascertained. To astronomers, therefore, we are much indebted for rectifying the errors of chronology, and affording fixed and sure points to which we may refer.

After 18 years 10 days, or 223 lunations, the sun and moon are in the same relative position in regard to each other. If, therefore, we have a list of all the lunar eclipses for one period, it is easy to ascertain when there will be eclipses in any future period.

But there are inequalities in the motions of the sun and moon, which render it somewhat uncertain.

The moon, in the course of her orbit through the heavens, sometimes comes over the planets, and for a certain time intercepts them completely from view. This is rarely visible with Mercury, but is of frequent occurrence with the other planets. It is precisely a total eclipse of these planets, and is of the same nature with a total eclipse of the sun.

As this phenomenon arises from the moon moving more rapidly through the heavens, it is her eastern side which first covers the planets, and they appear on the western side after their emersion.

The moon more frequently passes over a star, which is usually called the *occultation* of a star, and in the Nautical Almanac for any year it may be seen on what day and at what hour, minute, and second, the phenomenon will take place. When the moon has approached near to the star, in the twinkling of an eye the whole star disap-

pears, which is a proof that the apparent diameter is but a point. After a certain time, when the moon has passed over the star, it as suddenly all at once comes in sight.

The nearer planets sometimes, though very rarely, pass over those that are more distant, and sometimes a planet passes over a star. In the history of astronomy some instances are recorded as having taken place before the time of Jesus Christ. On the 9th of January, 1591, Mars covered Jupiter, and on the 3d of October the same year Venus covered Mars. On the 17th of May, 1737, Venus covered Mercury. In 1598, Kepler informs us that the planet Venus covered Regulus, or the Lion's Heart. In 241 before Christ the planet Jupiter covered one of the stars in the constellation Gemini, called the Southern Ass. In 1716 he covered Castor the largest of the Gemini.

The same phenomenon may also be exhibited by the comets, in the nucleus or solid part of a comet, covering a star, and

for a short while hiding it from view. Lalande observed a comet cover a star in the Swan on the 12th June, 1764.

When Mercury and Venus pass over the disk of the sun it is a phenomenon in every respect similar to an eclipse, and were their bodies large enough to obscure a sufficiently great portion of the sun, the appearance would be the same.

OF COMETS.

COMETS are a kind of heavenly bodies considerably different from planets, but much more nearly resembling them than the fixed stars. They are comparatively of rare appearance, particularly in our climate. By the aid of the telescope, and with the advantage of a clear sky, comets are more frequently seen. From 1789 to 1809 seventeen comets were seen in Europe. At first when a comet is seen it is very small, with a cloudy or nebulous matter about it; but as it advances through the heavens, which it does with great rapidity, it appears larger, and as it retires it as suddenly diminishes, and then entirely disappears. The time of continuing in sight is different in different comets. A comet is generally attended with a long tail, which appears longer and larger as the comet approaches the sun. This tail consists of some very thin matter, as is evident from stars being seen through

it. It is often many millions of miles in length.

Comets in the dark ages never failed to excite superstitious dread of approaching calamities. Among the prodigies enumerated by Virgil which presaged the death of Cæsar and the subsequent civil wars, comets held a distinguished place.

> ——Nec diræ toties arsere Cometæ.
>
> GEOR. i. 488.

Our great poet Milton has summed up the popular creed on the subject.

> On th' other side,
> Incens'd with indignation Satan stood
> Unterrify'd; and like a comet burn'd
> That fires the length of Ophiuchus huge
> In th' arctic sky, and from his horrid hair
> Shakes pestilence and war."
>
> PARADISE LOST, ii. 706—711.

Such ideas are at last happily exploded; but even now, should it be a wet season, when a comet appears, the comet is charged with being the cause of the rain, or should it happen to be extremely warm and

[illegible] It is often many millions of miles in length.

Comets in the dark ages never failed [illegible] superstitious dread or [illegible] Among the prodigies [illegible] [illegible] [illegible] comets hold a distinguished place.

[illegible]

[illegible]

[illegible]

Even a later poet, Milton, has summed up the popular creed on the subject.

[illegible]

[illegible]
Unterrified, and like a comet burn'd,
That fires the length of Ophiuchus huge
In th' arctic sky, and from his horrid hair
Shakes pestilence and war.

Paradise Lost, ii. [illegible]

[illegible]

dry, as was the case in the autumn of 1811, the comet has the credit, with as little cause.

If, as according to La Place, many comets be not larger in their nucleus or solid part than many mountains of our earth, it must be infinitely absurd to attribute to them any important effect on our globe, should they even approach much nearer than any has yet been known to do.

Of what matter the more solid part or nucleus of a comet consists, it is not easy to say. It is perhaps different in different comets, but there is reason to doubt its being very solid, for a comet which approached very near to Jupiter had no sensible effect on that planet or his secondaries, which would have been the case had the comet contained matter in proportion to its bulk.

The tail is supposed to be vapour raised from the body of the comet by the heat of the sun, and left in that form behind the solid part from its rapid motion. There are heat and motion enough to have this effect.

It is always in an opposite direction to the sun, it is so thin that stars can be seen through it; there is light reflected from it in the same manner as from vapour. A stronger reason than all for supposing the tail to consist of vapour is, that the nearer the comet approaches the sun the more extensive the tail becomes.

When the nebulous matter precedes the comet it is then called a *Bearded Comet.*

Aristotle imagined the comets to be merely meteors in the sky. Seneca foretold, with almost a prophetic wisdom, what would be the knowledge of these bodies to which mankind would arrive.

Kepler was the first who attempted to measure a comet's orbit.

Their orbits vary exceedingly from that of the planets in figure, for they come down near to the sun, and with an almost infinite rapidity whirl round and fly off into infinite space; and they differ from the other heavenly bodies in moving in orbits very oblique to the plane of the ecliptic, and also frequently in their progress through the heavens

going from east to west, in opposition to the order of the signs, which is observed by all the planets and their secondaries.

Notwithstanding astronomers by observation and mathematical investigation have determined the form of the orbit in which a comet moves, and have devised rules by which they may determine the time of its revolution, and when it ought to return; yet experience has hitherto done little to prove the accuracy of their views. Perhaps the comet, in its vast range into space, encounters the attraction of other bodies, and is carried off never to return, or its matter is entirely dissipated and it ceases to exist as a separate moving body in nature. In fact, only one comet has been sufficiently regular in its motion, to enable astronomers with any certainty to say, on its return, that it was a comet already observed. This comet was seen in 1531, 1607, in 1682, and last of all in 1756, and astronomers will expect to see it in 1835, or in the year before or after. The period of revolution is about 76 years, and its greatest distance

from the sun is about 36 times the length of the distance of the earth; but when nearest to the sun it is at little more than half the earth's distance.

Other comets have been suspected to have returned a second time, but it is impossible to be certain. It might have been different comets. In fact, we must wait with patience for time and observation to throw more light on the eccentric movements of these singular bodies.

A comet which was seen in 1680, was, when nearest the sun, only about the 66th part of the distance of the earth; and if, therefore, the heat received from the sun was in proportion to the intensity of light, inversely as the square of the distance, the comet must have received about 20500 times as much heat as bodies on the surface of our earth, which would be more than sufficient to reduce to a volatile state the substance of which our earth is composed. On the other hand, when removed to a just distance from the sun, the heat received at the surface from

[illegible] the [illegible] of [illegible] of the distance of the earth, and which appears to the sun [illegible] it will approach nearer than the perihelion distance.

Other comets have been suspected to have returned a second time, but it seems possible? [illegible]. It might have been different comets. In truth we must wait with patience for more and better observations, to throw more light on the economy of these singular bodies.

A comet which was seen in 1680, approached nearer the sun [illegible] about the [illegible] part of the distance of the earth; and if, therefore, the heat received from the sun be in proportion to the intensity of light, inversely as the square of the distance, the comet must have endured about 28,000 times as much heat as bodies on the surface of our earth, which would be more than sufficient to reduce to a vapour almost all the substances of which our earth is composed. On the other hand, when removed to its aphelion distance, it must have been exposed to [illegible] cold [illegible]

his rays, would be almost nothing whatever; but if the whole body of the comet was thoroughly heated, although the heat in all parts would be equalized, there would not be experienced great cold. In fact, the solid part of a comet is extremely minute, and therefore the heat would soon be rendered equal throughout every part of it.

As so much vapour is raised when the comet approaches the sun, the heat must be thereby moderated, as much heat is always absorbed or rendered latent by a body passing from a solid or fluid state to that of vapour. On the other hand, when vapour returns to a fluid or solid state much heat is given out, which must therefore increase the sensible heat of the comet, and diminish the effect of the great distance to which it removes from the sun.

The diameters of comets are so small as scarcely to be perceptible to the most powerful telescopes. In the nucleus of the comet of 1811, Herschel imagined he saw a bright point, which he supposed to be the disk of the comet itself. Only one comet

has as yet presented phases like the moon and planets, which all would have done, had they been more than a mere point. The comet which did so was that of 1531, 1609, 1682, and 1759.

The tails of comets extending many millions of miles from the nucleus, in their progress through the heavens, no doubt encounter various bodies which draw off a part, and it is certain, however, that in each return towards the sun the evaporable matter, and tails of comets, are diminished, and after a certain number of revolutions they are probably dissipated entirely, and the comet is either annihilated or only a small solid nucleus left behind, which becomes invisible at the earth. This may perhaps be the cause why so few comets, whose orbits have been calculated, have been known to return at the time supposed, to verify the conjectures of astronomers. The comet of 1770 ought from the figure of its orbit to have returned in five years and a half, but has never since been seen.

The mind is lost in conjecture whence

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The effect is [illegible] to [illegible]

comets come, for what purpose they are formed, what is their nature, and what end they answer in the economy of creation. We cannot bring ourselves to believe that they are habitable.

Whiston imagined, that the flood was occasioned by the tail of a comet or a comet itself coming in contact with the earth. It is unquestionable that were a very large comet to approach very near to our earth, the attraction would draw the waters towards it, and raise tides sufficient to drown the world. But that this really took place we have no knowledge.

It is also mere gratuitous assumption to imagine that another comet came of, a somewhat different nature, and carried off the water again from the earth; and it does not appear how, according to the laws of nature, any such thing could be effected.

their motions extremely slow & small

OF THE FIXED STARS.

It has already been noticed that there is a certain place in the heavens directly opposite to the north pole of the earth to which the axis of the earth if produced, would extend, which is called the north pole of the heavens, not far from which is the north polar star. This point is always at rest. Opposite to this point, in the southern hemisphere is another point, which is always at rest and is not visible on the north side of the equator, and which is called the south pole. Around these the whole of the stars seem to move once in the 24 hours. At London all the stars within $51\frac{1}{2}°$ of the north pole, such as the Great Bear, never go below the horizon.

The stars that are $51\frac{1}{2}$ degrees distant from the north pole, and not farther than $38\frac{1}{2}°$ south of the equator rise and set; and of these, the farther any star is north, the larger is its diurnal arc above the horizon.

refraction —

Thus Castor, whose north declination is about 32° 19′ rises at about 60° to the north of the eastern point of the horizon, and occupies about 19 hours in performing its diurnal arc. Regulus, whose declination is about 12° 57′ north, rises about 20° to the north of the eastern point of the horizon, occupies about 14 hours in its diurnal arc. Fomalhaut, whose declination is about 30° 41′ south, rises about 55° to the south of the eastern point of the horizon, and occupies about 5½ hours in its diurnal arc.

There is also a space towards the south pole which never comes above the horizon, which space is precisely equal in extent to that near the north pole, which never sets. To represent this clearly to the mind it is merely necessary to rectify the celestial globe for the latitude of any place. and make it revolve on its axis from east to west.

On casting the eye towards the stars, the first circumstance in their appearance which is observed, is their twinkling. The light of the sun, of the moon, or of a planet, is on the other hand steady. The twinkling

arises from the numerous particles of dust or vapours floating in the atmosphere, and constantly intercepting the particles of light which come to us from the stars. They are at such an infinite distance, that were not the light which comes from them to spread, they would appear merely of the size of the point of a needle. The largest of the fixed stars appear no larger when examined by a powerful telescope. In fact, the higher the power of the telescope, from its more completely cutting off the radiation of light, the smaller the star appears. On the other hand, when a planet which is comparatively near at hand is viewed, it appears larger and larger in proportion to the power of the glass employed. In very clear weather the stars do not twinkle very much, and in the fine clear atmosphere of Egypt or Arabia, where astronomy was first cultivated, the observers passing the night in the summer months on the tops of their houses, see the stars rise, hold on their course, and sink in the west, in a cloudless sky, and without twinkling, as with us.

The stars which are in view of the naked eye, at any one time, are much fewer in number than would at first be supposed. In a clear frosty night, on looking towards the heavens, they appear innumerable; but that is an optical illusion, arising from the reflection of light from particles floating in the atmosphere. To destroy the illusion, look steadily at any one place, and observe accurately what number of stars are really in view, and it will be found that they are not numerous. In fact, not more than about a thousand are to be seen at any one time by the naked eye.

The most natural way of representing the starry firmament would be to have a very large globe, into the interior of which the student might be placed, and by making it revolve it would represent the real heavens in miniature. It is clear that such a globe must be of immense size, and would require to be placed in a very large public building. One such globe was erected at Pembroke Hall, Cambridge, and is described in Long's Astronomy.

Every useful purpose is equally well answered by the common celestial globe, where the spectator is supposed to be on the outside of the apparent firmament of stars, and viewing the revolution of the heavens, as it would then appear. The rising, setting, the altitude above the horizon, or the depression below it, the arcs described above the horizon, and the arcs below it, and the relative position of the stars to each other, and their position in regard to the earth at any hour of the night, are represented equally the same.

The young student who first sees the celestial globe, and the figures of men, animals, &c. upon it, is sometimes led to expect to see such resemblances in the heavens themselves. These he will not find, and it never was intended he should. When certain stars were first observed, and laid down upon the globe in their proper places, it was thought a convenient way of being able to find these again, to paint some figure over them. Thus, if we are told of a star in the Flying Horse, we look for that figure

in the globe, and then we easily can find the star referred to. A star in the neck of the Swan is found at once by the figure of that bird painted on the globe. In some globes the stars are laid down, and the outline of the constellation given, without the figure being painted; but this is less convenient, as it is a longer time before a star can be found; and as books of astronomy often name the limb, or particular part of the animal, it is often impossible to be sure which is the star, on a globe of this sort.

The stars in the constellations are distinguished by the letters of the Greek alphabet.

The largest star in any constellation is called α, the second β, and so on. When the Greek letters have been all employed, astronomers then use the Roman letters, a, b, c, and so on; and when it is still necessary to distinguish more stars, they then use the common numbers, 1, 2, 3, &c. as far as necessary. It would have been much simpler, and less pedantic, to have used

these numerals only for all the stars of any constellation.

The fixed stars appear to us of different sizes, and have usually been classed into seven magnitudes. In assigning the stars to their different degrees of magnitude, there is not always a certain rule. A star may be of that size, that it may be classed by some amongst the stars of the first magnitude, and by others among those of the second, but such a star will never be classed amongst those of the third. Again, there are stars of which it is doubtful whether they ought to be classed amongst those of the second or third magnitude, but none will have any difficulty in seeing that they cannot be said to be either of the first or fourth magnitudes. The stars of the sixth magnitude are the smallest stars at all visible to the naked eye, and of course stars of the seventh magnitude are only to be seen by help of the telescope, and are usually called telescopic stars.

Catalogues of the stars were made in the

times of antiquity. Pliny informs us, that Hipparchus, who lived about 120 A. C. on the appearance of a new star set about making a catalogue of the stars, noting their exact position and apparent magnitude, that in future it might be known if any new star appeared, or any star disappeared, or if any star changed its place or its appearance.

Ptolemy, about A. D. 140, in the beginning of the reign of Antoninus Pius, made a catalogue of stars, copying chiefly from Hipparchus, but making such alterations as appeared necessary to render the catalogue correct. The number of stars of which he gives the place is 1206.

Ulug Beigh, grandson of Tamerlane, made a catalogue of stars, with their places, in 1437. His catalogue contains 1022 stars.

The learned Danish nobleman Tycho Brahe, spent many years in the island of Huen, observing the places of the stars. His catalogue, published after his, death with their places for 1600, contains only 777 stars.

A very complete catalogue was published by Flamstead, astronomer royal at Greenwich, both of the stars of the northern and southern hemisphere, with their places for the year 1689. The number of stars in the whole catalogue is not less than 3000, but many of these are only visible by means of the telescope.

Although the celestial globe was first made amongst the Egyptians or Arabians far south of Greece, yet when it was introduced amongst the Greeks, they changed the names, and sometimes the figures of some of the constellations, and many of the heroes of the Argonautic expedition, which was then in high admiration amongst the Greeks, had the honour of having tracts of heaven called by their names. The names of some stars in the southern part of the heavens, not seen from Greece had Grecian names imposed upon them. Of these we have an instance in the ship Argo, which was not visible from Greece, and which was laid down in commemoration of Noah's ark.

A very complete catalogue was published by Flamsteed, astronomer royal at Greenwich, both of the stars of the southern and northern hemispheres, with their places for the year [illegible]. The number of stars in the whole catalogue is not less than [illegible], but many of these are only visible by means of the telescope.

A design for the celestial globe was first [illegible] the Argonauts [illegible] the north of Greece, [illegible] when it was [illegible] amongst the Grecians, they [illegible] the heroes, and [illegible] the figures of some of the constellations, and [illegible] the history of the Argonautic expedition, which was held in high admiration amongst the Grecians, and the honour of having [illegible] exploit of their nation. The number of [illegible] in the southern part of the [illegible] the Grecians [illegible]. Of these [illegible] the Ship Argo, [illegible] not visible from Greece, and [illegible] in commemoration of [illegible]

The southern constellations exhibit to us the history of Noah, and are a collateral proof of the truth of the history given in the Bible. The River Eridanus or Po, as it is called in our globes, was not visible from Greece or Italy, and the constellation must have been laid down by the Ethiopians, Arabians, or Egyptians; it in fact means Noah's flood. The ship Argo is Noah's ark. The raven sent out by Noah is also seen in the globe. The crater or cup, in which Noah drank his wine, and the altar on which he sacrificed, also preserve that part of his history. Modern astronomers have added Noah's dove.

The best method of all, when any very bright star is seen in the heavens, to tell what star it is, is to have recourse to the celestial globe. Rectify the globe for the latitude of the place, which is done for London by raising the north pole to $51\frac{1}{2}°$ above the north side of the wooden horizon; then find the sun's place in the ecliptic for the day of the month required, and bring it to the meridian, and set the index to

twelve o'clock. This gives us the precise position of the heavens that day at twelve; and by turning the globe round from east to west, we have the position of the heavens at any hour we please, as may be seen by looking at the index of the hour circle. Having then the position of the globe for the given day and hour, we may see what stars are in the east, what towards the west, or on the meridian, or in fact, on any part of the heavens, the globe being then an exact counterpart of the heavens themselves.*

It is remarkable that there are stars which have appeared, which were never known to have been in the heavens before, and stars have also disappeared, and have again become visible.

Various conjectures have been made to account for this phenomenon. It has been supposed that a star which has become visi-

* Much assistance may be obtained by the student from "Frend's Evening Amusements," published annually, which state the remarkable phenomena to be seen any evening throughout the year.

ble, has been at its creation at such a boundless distance from our earth, that its light had not till that time reached us. This conjecture is at least possible. Other astronomers had supposed the stars to have a very slow revolution on their axis, and that one side was dark and another bright, and that the bright side being presented to us the star was then seen, and as that part of the heavens had not been much observed before, it was supposed to be then seen for the first time. This is the conjecture of Riccioli and Bouilland. Maupertuis supposes, that the stars in revolving had become flattened like a plate, and that when the thin edge was presented to the earth by the attraction of some heavenly body, the light emitted by it was not sufficient to render it visible. The attraction of some heavenly body might again present the broad part towards the earth, when the star would again be visible. This it is supposed may account for a star changing its magnitude and colour. Should the thin side be brought round, so as to be presented to the earth,

and no cause afterwards alter the position, the star would be supposed to be lost for ever. The total destruction and annihilation of a star may also take place.

There is, however, reason to believe, that many stars, which were supposed to appear and to disappear, were only comets; and this is the more likely, as such things are of less frequent occurrence since the heavens began to be explored with greater accuracy and by a greater number of able astronomers.

As for the stars which are sometimes dark, and other times splendid, we may suppose the cause to arise from very large spots upon them, not adapted for the emission of light, or from opaque bodies revolving round them, which may intercept the light they emit.

Of the stars which have changed their appearance, none has been more remarkable than one that appeared in the constellation Cassiopeia in 1572. In alittle time it surpassed in splendour all the stars, and even the planet Jupiter. Its light after-

wards diminished, and it at last became totally invisible about 16 months after its first appearance. In this time it had not changed its relative position in regard to the other stars. The colour was at first white, then a yellowish red, and before it was finally lost of a lead colour. We are led to imagine, that in such cases there is a conflagration of a most terrific nature in the star.

One part of the heavens can scarcely have escaped any person's observation, that part is the MILKY WAY. It is a bright clear circle, extending all the way round the heavens. The ancient fables ascribed it to milk that fell from Juno's breasts, and others ascribed the honour of its formation to Phaeton. Aristotle supposed it to be a meteor; and Democritus and Manilius thought the phenomenon was occasioned by an innumerable multitude of small stars, which, though invisible to the naked eye, gave out a blaze of light. Several modern astronomers have adopted the same opinion, amongst others, Cassini; and it was sup-

posed that observation confirmed the truth of this conjecture, for on directing a telescope of great power towards the Milky Way, stars innumerable are every where presented to the eye. La Caille and La Lande, however, doubted the truth of this explanation, and with great justice; for if the telescope be presented to any other part of the heavens, stars innumerable are there also seen. Were the stars then to occasion a light like that of the Milky Way, why not in every other part of the heavens also? This objection is unanswerable, unless we suppose that the stars of the Milky Way are nearer to us, and are more brilliant than the others, which may be conjectured, but cannot be shown to be true.

There are particular places in the heavens more brilliant than others to which the name of NEBULÆ or clouds have been given. They have been supposed to be a collection of extremely minute stars like those in the MILKY WAY, but the same objection as already stated may be brought against this explanation, that there are an

equal number of stars seen in places of the heavens where no such light is perceived. It has been supposed to arise from a cloudy matter, extremely rare, which is sometimes expanded, and which occasions the variety of appearance they present. A beautiful nebula in Orion has frequent changes of appearance.

Some of the stars, when seen by the naked eye, appear very large. Albategnus conjectured they were 45″ in diameter; Tycho Brahe imagined as much as 60″; Riccioli supposed 18″; Galileo thought Lyra was 5″; Kepler supposed Sirius 4″ in diameter, but afterwards was of opinion that the largest of the stars were but mere points. From observations in Regulus, Aldebaran, the Virgin's spike, and Antares, at their occultation, it is ascertained they are less than 1″. When the moon comes near them, they disappear in an instant of time, less than the twinkling of an eye.

It is a discovery for which we are indebted to the telescope, that some stars which appear to the eye to be single, are found

to be in reality two stars so nearly in the same direction from the earth, that the light proceeding from them intermixing, they appear to the eye to be but one. Of these double stars are ζ of the Lyre, γ of Aries, and α of the Hydra, α of the Centaur, ο of Capricorn, α of Hercules, δ of the Lyre, α of the Gemini, γ of Andromache, and μ of the Swan.

Some stars are found to be treble as ν of the Lyre.

Some stars are quadruple or double double; as β of the Lyre, λ of Orion, ζ of Libra.

Though almost all the stars have from the time of the earliest observations remained unchanged in the same place, yet there are some exceptions. These are Aldebaran, Regulus, Sirius, Arcturus, Rigel in Orion, Capella, and δ of the Eagle. These stars have in a very small degree departed from the position they were in, as laid down by Ptolemy, or even from the place they were in when observed by Tycho Brahe. These stars, which are of the first magnitude, are all not far from each other, and it is conjec-

tured may have, by means of attraction, some effect one upon the other.

The science of astrology has occupied much of the attention of mankind, and it may be amusing to the reader to know the principles upon which it is founded. It is true that pretenders to astrology now are mere impostors on the credulity of the ignorant; but in former times the professors of this science were sincere in their belief, and had principles on which they founded their calculations of good and evil which were to come to pass. When it was once believed that the stars presided over human destinies, it was an easy step farther to observe what great star rose at the birth of any great man's son, and consider that to be the ruling star which presided over his fate. If, in future life, he was prosperous and happy, that star was considered as a happy star. Then the position of other stars would be observed also. It would happen that in different circumstances the same star would give a favourable omen, and in others an

unfavourable, and different stars would give different results: it was therefore the business of the astrologer to calculate all the different effects likely to be produced by the stars, and to balance one thing against another, thus "fatis fata contraria rependens," to determine at last on good and evil to come. The planets were in a particular manner to be studied, as having a ruling influence, and their positions at the time of birth were particularly to be ascertained, and as many cases as possible collected of the lives of persons born under different aspects, from thence to calculate, by comparing the good and the bad, what was to be the fate of the person respecting whom inquiry was made.

In order, therefore, to determine any person's nativity, it is necessary to know the precise time and place of his birth. Then having rectified the globe for that place, and adjusted the globe so as to give the exact state of the heavens at that time, it is then necessary to know in what place are

the different planets. Any large star towards the east will be the ruling star, the influence of which may be counteracted by other stars, and the power of one planet may coincide or oppose that of another. It was usual to divide that part of the globe which was above the horizon into six divisions, called houses, and that below the horizon into as many, and draw inferences according to the stars or planets in the different houses, according as their good or bad influences had been ascertained by previous experience.

Such is an outline of this absurd science. If a great star rose when a prince was born, it did so also to a beggar; if one man was successful and its influence was presumed to be happy, another man was unfortunate under the same star. Yet for many ages men sought to penetrate into futurity by such observations and calculations, and when unsuccessful they supposed, not that the science itself was absurd, but that they omitted important facts in their calculations,

or had committed an error. In our time, astrology is known to be baseless as the fabric of a vision, and pretenders to it are mere impostors who know nothing of the stars, and merely avail themselves of the credulity of the ignorant to rob them of their money.

OF THE DIVISIONS OF TIME.

THE division of time is a matter which is highly important, and has occupied the attention of men in all ages of the world. Time, according to the metaphysicians, is measured by the current of ideas which pass through the mind. Mankind have found natural divisions of time in the motions of the heavenly bodies, into days, weeks, months, and years.

The natural day is marked out by the rising and setting of the sun, and the intermediate space from sun-set to sun-rise is called the night. As the year has been divided into 12 months, so from analogy the day has been divided into 12 hours; as has also the night. Different nations have had different customs as to the time of commencing the day and dividing it into hours. The Jews and the ancient Greeks and Romans began the day at sun-rise, and divided it into 12 hours until sun-set. An hour in

summer was therefore longer than an hour in winter. The night was divided in the same manner, or into the military distinction of watches, of which there were 4 between sun-set and the morning. The modern Italians still begin the day at about half an hour after sun-set, and count the hours regularly until 24 o'clock, which is half an hour after sun-set. This method is extremely inconvenient, as it makes the day begin at a different time at different seasons of the year, and the same nominal hour does not correspond with the same time of the natural day. Most nations begin the day at midnight, which makes 12 o'clock always at mid-day. Astronomers and sailors, however, begin the day 12 hours later, at 12 o'clock in the day; and in almanacs, log-books, &c. the hours go on regularly to 24.

When astronomers come to find what is the exact length of the day, it is found to be a matter of greater difficulty than at first it might be supposed. The time which a star takes from passing the meridian to come exactly to the meridian again, is called

the sidereal day. This, however, is not exactly the same with the solar day. For as the sun has a motion through the heavens, from west to east, in opposition to his diurnal motion, he has proceeded a certain way towards the east from the time he has passed the meridian to his return, and therefore he has that to make up. Suppose then that the sun and Regulus passed the meridian at the same instant to-day, to-morrow the sun would be a little later than the star. In most days the difference is nearly 4 minutes. In short, the sun falling back so much every day, and going round the heavens once in a year, passes the meridian once less than the star in a year.

The solar days are not always equal. One cause is because the sun does not move through the ecliptic an equal space at all times of the year. At the summer solstice, June 21, when the motion of the sun is slow, there will be less difference between the solar and sidereal day than at the winter solstice, when the sun moves more rapidly. This difference of the apparent

motion of the sun through the stars, entirely arises from the difference of the rapidity of motion of the earth in her orbit, which is greatest when she is nearest the sun, and slowest when she is most remote. Another cause of the inequality of the length of the solar days is the obliquity of the ecliptic. If two suns were to start from Aries to go on to Libra, the one along the equator, and the other along the ecliptic; the sun which moved along the equator, excepting so far as his motion was affected by the cause of variation already stated, would always be exactly twenty-four hours in coming to the meridian; but the sun which proceeded along the ecliptic, which is the course of our sun, would be sometimes sooner, sometimes later. This difference is called by astronomers the ascensional difference, and is easily shown by the celestial globe.

The division of time into weeks of seven days was a divine appointment, as we learn from the sacred scriptures.* Tradition might

* Genesis, i. Exodus, xx.

preserve this division amongst all nations, but this uniformity was corroborated by astronomical observation. From new moon to full moon is a fortnight, or two weeks, the half of which, from new moon to the half moon, made a week. Of the universality of the custom throughout the world we have abundant authority.*

The motions of the moon suggested the division of time into months. From one new moon to another, or from one full moon to another, are 29½ days. Hence, the most barbarous nations know how to reckon time by moons. It was the custom of the Greeks, and for some time with the Romans, to reckon twelve lunar months to the year. As twelve lunar months make only 354 days, the Roman Pontifex Maximus occasionally added an intercalary month to the year, which gave him considerable importance, by enabling him such year as he pleased, to keep the annual magistrates a month longer in office. The Mahometans still reckon by

* Grotius, de Veritate, i. § 16.

lunar months, which is extremely inconvenient. Suppose their year to begin any year the same day with ours, there being only 354 days in a lunar year, their year must begin next time on our December 20th, and the year after December 9th, and so on, moving back eleven days every year, and as they do not reckon leap year, also losing another day every fourth year. In consequence of this, their months begin in different parts of the season, and when the month Ramazan falls in the long days of summer, as fasting is rigorously observed during that month, from sun-rise to sun-set, the labouring classes, who cannot afford like the rich to sleep by day and feast by night, suffer hardships probably little contemplated by the Arabian prophet, since at the latitude of his native place, there was not so much variation in the length of the day in the different seasons.

The year, as indicated by the motion of the sun, is the division of time most proper, as it always gives the same length of the day and the same state of the seasons,

at the same period. To determine the real length of the year, was in the early ages of science a most difficult matter, and whoever will consider with himself how he would effect it, will at once find it a thing not to be brought within even very inaccurate limits, without much ingenuity, and close observation. As the weather is often so unlike in two successive seasons, any observation of that sort could not determine the length of the year, by a great number of days. The only way by which it could be done, was by observing the length of the shadow made by the sun at the longest and shortest days.

As the sun is higher in the heavens at twelve o'clock on the longest day, than at any other time, the shadow of any object, as of a tower, or obelisk, or gnomon erected for the purpose, will then be the shortest.—On the other hand the tower or obelisk will cast a longer shadow at twelve o'clock on the shortest day, than on any other day of the year. When this was known, and when men devoted themselves

to observe the heavenly bodies, it was not difficult to ascertain the number of days in the year.

The most ancient observation of this kind that we meet with, is that made by Pytheas, in the time of Alexander the Great, at Marseilles, when he found the height of the gnomon was to the meridian shadow at the summer solstice as $213\frac{1}{8}$ to 600, just the same as Gassendi found it to be, by an observation made at the same place, almost 2000 years after, in the year 1636.

Pliny tells us, the shadow of the gnomon at Rome, at the Equinoxes, was to the height of the gnomon as 8 to 9. By an easy calculation in plane trigonometry, we thence find the height of the equator 48° 22″, which gives the latitude 41° 38′.

The most ingenious kind of gnomon is that which admits a ray of the sun, by a hole in a plate of metal, in the roof of a church upon a meridian line in the floor. The most celebrated of this kind is that made by Cassini in the great church of St. Petronius at Bologna, in Italy.

The great pyramid of Egypt which is built with its four square sides exactly north, south, east, and west, was employed for this purpose. At Lacedæmon was an obelisk to determine the length of the year. The Caliph at Samarcand had a tower erected for this purpose. A Spanish historian informs us, that even the Peruvians had fallen upon this method of finding the longest and shortest day.

It is extremely probable that the year was at one time believed by the Egyptians to consist of 360 days, which in fact continued to be its length in their calendar, only they added at the end of it 5 intercalary days, which were observed as holidays. The circle of the heavens, like all other circles, was divided into 360 degrees, which no doubt took its origin from the belief that the sun passed round the heavens in 360 days; and that he passed one of those degrees in a day. The utmost exactness and observation would be required to find the length of the year, as to the number of days, without regarding any excess

of hours and minutes, which would only be discovered after a long period of time. It would be effected by drawing a meridian line, and a number of concentric circles, and the length of the shadow would afterwards serve to point out at any time the season of the year.

The discovery that the year consisted of 365 days is mentioned by Herodotus five centuries before Christ; but Plato and Eudoxus about 80 years afterwards, learned that the year consisted of 365 days 6 hours. When Julius Cæsar, in his character of Pontifex Maximus, set about reforming the Roman calendar, he fixed that 3 years successively should consist of 365 days, and the following year of 366 days, which was called Bissextile, and is with us called Leap Year. As, however, the year is not quite so long as 365 days 6 hours, but only 365d. 5h. 48′ 49″ the consequence was, in the course of time, that the commencement, as determined by the Julian calendar, was 10 days later than the real course of the seasons, and several moveable feasts of the

church were deranged in the time in which they ought to be observed. Pope Gregory, therefore, decreed that 10 days should be struck out of the calendar after October 4th, 1582; so that the following day, instead of being called October 5th, should be called October 15th; and in order that the same error might not arise in the course of time, he ordered certain years to be reckoned only common years, which are 1700, 1800, and 1900, which instead of being leap years as being the fourth from the preceding leap year, were to have only 28 days in February as common years. This regulation will, for a long period of time, keep the same day of the month at exactly the same season of the year. This is what is called New Style, and was immediately adopted in all countries which acknowledged the papal authority, but was not introduced into England till 1752, when it was received by act of Parliament. As 1700 and 1800 were considered only common years instead of leap years, as by the old style, the difference

between the old and new style is now 12 days. Hence a letter from Russia, dated July 4th, would be written on the same day as July 16th in England. In reading of any event in English history previous to 1752, it is necessary to recollect the difference of the old and new style, which before 1700 was 10 days, and between 1700 and 1800 was 11 days. Thus the battle of Culloden, fought on April 16th, O. S. would by the present style be said to have been fought on April 27th, 1745.

OF THE DIVISIONS OF THE GLOBE, AND OF LATITUDE AND LONGITUDE.

THE POLES of the earth are those points which are at rest, and are constantly directed towards the same place in the heavens, namely, to a point near the north polar star in the northern hemisphere, and to a place within the square formed by four large stars which are near the southern pole of the heavens.

The EQUATOR is a line drawn round the earth, of which every part is exactly at an equal distance from either pole. At the equinoxes, either on the 1st of March, or on the 23d of September, the sun is directly perpendicular to this part of the world.

The TROPIC of CANCER marked on the globe, is that part to which the sun is perpendicular at the longest day. The inhabitants, at twelve o'clock, then have the sun

directly over their heads. At that time the light of the sun will reach just as far as the ANTARCTIC CIRCLE on the southern part of the world, and, therefore, at our longest day all within that circle will be in darkness the whole of the twenty-four hours. As the tropic of Cancer is about 23° 28′ north of the equator, so the antarctic circle is just the same distance from the south pole. The light of the sun must necessarily illuminate one half of the globe at once, and will therefore extend 90° on either side of that part to which it is perpendicular; when therefore the sun is at the tropic of Cancer his light will reach beyond the north pole 23° 28′, and all within that distance of the north pole will be illuminated the whole of the twenty-four hours. The boundary line of this illuminated part is called the ARCTIC CIRCLE When the sun has retired to his farthest distance from us, at our shortest day on the 21st of December, he is then directly perpendicular to the tropic of Capricorn, and at twelve o'clock the inhabitants see him directly over their heads. As he is then

23° 28′ south of the equator, his rays must then reach 23° 28′ beyond the south pole, and all places within that distance of the south pole, in other words within the antarctic circle, must enjoy perpetual light the whole of the twenty-four hours. On the other hand, being 23° 28′ from the equator, his rays cannot reach farther than to the arctic circle, which is 23° 28′ from the north pole, and all within the arctic circle must then be in perpetual darkness.

The poles of the earth, the equator, the tropic of Cancer, and the tropic of Capricorn, the arctic and antarctic circles, are therefore laid down upon the artificial terrestrial globe, as having their origin in nature.

After our shortest day, as the sun advances on through the ecliptic, he is every day becoming perpendicular to places nearer and nearer to the equator; his rays will of course penetrate farther and farther every day beyond the arctic circle, and so far less beyond the south pole; it will therefore follow that more and more of the country

within the arctic circle will cease to be involved in perpetual night, and less and less of the space within the antarctic circle will be illuminated with perpetual day. When the sun is perpendicular to the equator his rays extend exactly from pole to pole; but as he advances on through the ecliptic, and becomes perpendicular every day to places farther and farther north, more and more space around the south pole is involved in perpetual darkness, and more and more about the north pole has perpetual light, until he reaches the tropic of Cancer, when all within the arctic circle is perpetual light, and all within the antarctic circle is perpetual darkness.

Exactly similar phenomena now begin to take place as the sun gradually retires towards the equator, from it onwards to the tropic of Capricorn.

Latitude is the distance of any place from the equator, and is expressed in degrees, minutes, and seconds, each degree containing 60 minutes and each minute 60 seconds. There are 90 degrees from

the equator to the pole. Each degree contains about 69¾ English miles. There are various circles drawn on the globes parallel to the equator, to assist in finding out the degree of latitude, and they are called parallels of latitude.

It is comparatively an easy astronomical observation and calculation to ascertain the latitude of any place. It is only necessary to find the height of the pole of the heavens at that place. At the equator, which has no latitude, the pole of the heavens is in the horizon; at the pole itself of the earth, the pole of the heavens would be 90° high, or exactly perpendicular. At any intermediate place the height of the pole would be exactly the latitude of that place.

The latitude of any place may easily be determined by ascertaining the altitude of the equator above the horizon. From the north to the south point of the horizon are 180°. Of these degrees there are 90° between the equator and the pole; and therefore from the horizon to the equator on the meridian line, and from the pole to the hori-

zon there are together 90°. If, therefore, we find the altitude of the equator, and subtract it from 90° we have the altitude of the pole or the latitude of the place.

The altitude of the equator may easily be known by observing the altitude of the centre of the sun at twelve o'clock. Suppose the sun's altitude 48° 13′, and his declination on that day, as found in the table, to be north of the equator 7° 10′; by subtracting 7° 10′ from 48° 13′ there remains 41° 3′, the height of the equator, and that subtracted from 90° will give 48° 57′ north, the latitude of the place. Again, suppose the sun's altitude to be 44° 25′ and that his declination is 12° 18′ south of the equator, these two added together make 56° 43′ for the altitude of the equator, which subtracted from 90° make 33° 17′ north, the latitude of the place.

In order to determine the latitude in the main ocean, the sun's meridian altitude is observed every day at twelve o'clock.

The altitude of the equator may also be known by taking the altitude of any large star when crossing the meridian, and the

are these are together 90°. If, therefore, we find the altitude of the equator, and subtract it from 90°, we have the altitude of the pole or the latitude of the place.

The altitude of the equator may easily be known by observing the altitude of the centre of the sun at noon [illegible]. Suppose the sun's altitude 48° 10′, and his declination on that day, as found in the table, to be north of the equator 7° 10′; by subtracting 7° 10′ from 48° 10′ there remains 41° 0′, the height of the equator, and that subtracted from 90° will give [illegible] north, the latitude of the place. Again, suppose the sun's altitude to be 34° 12′, and that his declination is 16° 18′ south of the equator, these two added together make 50° 30′ for the altitude of the equator, which subtracted from 90° makes 39° 30′ north, the latitude of the place.

In order to determine the latitude in the [illegible] the sun's meridian altitude is observed exactly as before mentioned.

The altitude of the equator may also be known by taking the altitude of any fixed star, when crossing the meridian, and the

calculation is so far easier, as the declination of the star or its distance from the equator is always the same. Thus, suppose the meridian altitude of Aldebaran to be 64° 17′, by substracting his declination on the north of the equator 16° 8′ we have 48° 9′ for the altitude of the equator, which gives the latitude 41° 51′ north.

To make these observations with sufficient correctness to answer the purposes of navigation is extremely easy, but to find the LONGITUDE is often an extremely difficult problem. Let us suppose a line drawn from the north pole through London, and continued on to the south pole, that line would be the meridian of London, and the number of degrees and minutes any place was situated from that line, would be its longitude either east or west as the place might be.

Different nations have adopted different meridians; thus whilst the British adopt the meridian passing through London, or to speak more exactly through the observatory in Greenwich Park, the French make use of the meridian of Paris, the Dutch that of

the island of Ferro in the Canary isles, the Americans that of Washington, their federal city.

The longitude of any place is counted upon a circle supposed to be drawn through that place parallel to the equator. By looking at the globe many such circles may be seen. Such circles are smaller the farther they are from the equator, and the nearer to the poles. At 60° latitude such a circle is just one half the size of the circle of the equator. All the circles are however divided into 360 degrees, each degree containing 60 minutes, and each minute 60 seconds. Therefore the length in miles of these degrees will be different in different latitudes, and we cannot tell how many miles one place is east or west of another merely by knowing the difference of longitude.

Finding the longitude is a much more difficult matter than finding the latitude. Of the various methods by which it is done, that of finding the difference of time betwixt the first meridian and the place in question is the easiest, where it can be applied. As

the earth revolves round its axis in 24 hours, when it is twelve o'clock at London, a place 15°, or [illegible] of 360°, east of London, will have its one o'clock in the afternoon; and on the other hand, a place 15° west of London will have it only 11. For any greater or less number of degrees there will be a proportional difference of time. Hence, if we know the difference of time, we can easily convert it into degrees, minutes, and seconds of longitude in the proportion of one hour to 15 degrees. Example. Suppose it to be half past 8 when it is 12 in the city of London; required the longitude. The difference of time is 3½ hours. A [illegible] 52½ degrees of longitude; and as the time is before that of London, the place is to the west.

It is easy to find the time of the day at any place, as it is exactly 12 when the sun is on the meridian, and at its greatest height for the day.

Time may also be observed by a variety of instruments [illegible] [illegible]

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Finding the longitude [illegible] more difficult [illegible] Of the various methods by which it is done, [illegible] the first meridian [illegible]

the earth revolves round it axis in 24 hours, when it is twelve o'clock at London, a place 15°, *i.e.* $\frac{1}{24}$ of 360°, east of London, will have it one o'clock in the afternoon; and on the other hand, a place 15° west of London will have it only 11. For any greater or less number of degrees there will be a proportional difference of time. Hence, if we know the difference of time, we can easily convert it into degrees, minutes, and seconds of longitude by the proportion of one hour to 15 degrees. Example:—suppose it to be half past 3 when it is 12 in the day at London, required the longitude. The difference of time is $3\frac{1}{2}$ hours. As 1 hour : 15° :: $3\frac{1}{2}$: 52° 30′, longitude sought; and as the time is before that of London, the place is to the east.

It is easy to find the time of the day at any place, as it is exactly 12 when the sun is on the meridian, and at his greatest height for the day.

The same may also be observed by a variety of observations of the heavenly bodies. Now the hour at London is known by Har-

rison's time-keeper, which is so perfect a piece of mechanism, that the errors it will make during a voyage are very inconsiderable, and being therefore set at London will go exactly and show what is the London time.

Harrison's time-keeper is very expensive, and after a length of time it will not be perfectly correct, which is a matter of very great consequence, as every minute of error in time occasions 15′ of error in longitude. Hence other means must still be resorted to.

The eclipses of Jupiter's satellites furnish the means of determining the longitude. In the Nautical Almanac is laid down the moment the satellite disappears or comes in sight at London; if such a phenomenon therefore be observed, and the exact time at the place of observation be ascertained, the difference of time between London and that place is known, and a simple rule of three calculation, as in the former case, gives the difference of longitude. The longitude of places on the land is best ascertained by such an observation. At sea, however, it

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is impracticable, as the rolling of the ship renders it impossible to view Jupiter correctly through the telescope. Also if a ship stop in any harbour of án unknown island, and the telescope and other instruments be taken on shore, the disappearing or reappearing of Jupiter's satellites happens so rarely, that there will seldom be an opportunity of making such an observation. The same may be said of many other celestial phenomena, as the transits of Mercury and Venus, which would give a good result were they to occur more frequently, and could they be observed on board-ship where finding the longitude is a most important operation of every day's occurrence. Navigators have had recourse to another method, that of observing the distance of the moon from the sun or from any fixed star, and by a long and intricate calculation they thence make out the longitude. It is still a desideratum in navigation how to ascertain the longitude at sea by a method easy of performance, and at the same time sufficiently correct to guide the course of the vessel.

In the Nautical Almanac all the calculations are made and tables given, by which the labour of the sailor on ship-board may be facilitated in finding the longitude according to the methods now in use; but after every assistance that can be given, it is a difficult and tedious operation.

In the Nautical Almanac all the calcula-tions are [illegible] by which the distances of the moon [illegible] the facilitated to deduce the longitude ac-cording to Greenwich [illegible] but also every calculation that can be [illegible] in a [illegible] [illegible]

OF THE TIDES.

Whoever has been a short while near the sea-coast must have observed that at one time the waters have retired very far and left a large portion of the shore, whether rocks or sand, dry, so that a person might go down upon it and gather sea-weed or shells; and in a short while the water has begun again to rise, and gradually coming up farther and farther, at last has come up very high and covered a large space of ground.

A person at a sea-port town must soon observe the ground in the harbour dry, and the ships resting on the mud, or lying a little on one side; and gradually the water again entering, the boats and ships floating, and a depth of water of ten, fifteen, or twenty feet, close by the pier.

When the sea retires to its greatest distance it is said to be Low water, and the part of the shore immediately next the water is called the Low Water Mark. When the water rises to its greatest height it

is called HIGH WATER, and that part of the shore to which it then extends High Water Mark. The intermediate space, at one time left dry, at another time covered with water, is the shore between the high and low water mark, and in England when it is dry is a part of the adjoining county, and subject to the usual authorities; but when covered with water is a part of the ocean, and subject to the Court of Admiralty.

Where the water is very shallow, as it is in some sandy bays, the space of ground left dry is very extensive. Near the Solway Firth the sands left dry are many miles in extent, and a very little rise in height must make the waves therefore overflow rapidly to a great distance. The imprudent traveller, who has held on his way across the sands, has often suffered for his forgetfulness of the rise of the tide.

Where there are steep lofty rocks overhanging the ocean, and as is almost universal in that case, deep water beneath them, the only difference occasioned by the tide is, that

at low water a certain number of feet of the edge of the rocks is seen, which are hid from view when the water rises by the coming in of the tide.

Such are the phenomena of the tides of the ocean, as presented every day on the sea-coast. In rivers within the tide-way, it may be observed, that for a certain number of hours the water, instead of running down towards the sea, rises, and runs in a stream contrary to the usual direction of the current, and there being then a much greater depth of water. This may be at any time observed in the Thames, at any place below Richmond, to which the tide rises. After high water the current of the river again descends in the usual manner, and runs down a greater number of hours than it ran up, as the river has not only to discharge the water brought up by the tide, but also the water which has flowed down, and keeps flowing down, from the interior of the country.

From high water to high water the time is about 12 hours 25 minutes, so that it is

twice high water and twice low water in 24 hours 50 minutes. The tides, therefore, do not return at the same hour every day. If it be high water at twelve o'clock to-day, it will be high water to-morrow about 50 minutes past 12, and on the second day at 40 minutes past one, on the third day at 30 minutes past two, on the fourth at 20 minutes past three, and so on.

It is remarked that at new moon or full moon, the time of high water is always the same at any one place. On these days the tide also rises higher than at any other time, and is called SPRING TIDE; and at low water, on the same days, the tide retires farther out, and leaves a larger portion of the shore dry. In some harbours large ships have sufficient depth of water to come in or go out at high water at spring tides, when there is not sufficient water at any other time. Every succeeding day the tide will rise less and less for about a week, when it is said to be NEAP TIDE, when the water neither comes up so far at high water, nor retires so far out at low water, as at

other times. After this the water comes up farther and farther every day for about a week, when it is again spring tide.

From a little after low water to nearly high water, the tide runs from north to south, on the coast of Britain and a greater or less number of miles an hour according as it is nearer or further from spring tide. If the tide be confined by islands or by sand-banks it will run in a very rapid stream. Thus in the Pentland Firth, which lies between the North of Scotland and the Orkney Isles, the tide, at spring tides, runs about nine miles an hour. The tide runs very rapidly in the channels between the sand-banks on the coast of Norfolk and Suffolk. After remaining still for a short while at high water, the tide again runs northwards, in an opposite direction, for an equal length of time, and again remaining still for a short while at low water, recommences its course southwards.

When a vessel, therefore, is proceeding along the coast for six hours, the tide is in her favour, but after that time the tide for

six hours is against her, and unless, therefore, there should be a sufficiently strong breeze to carry her forward in the face of the tide, it will be necessary to cast anchor, and wait for six hours. As the tide is still for some time at high and low water, then is the proper opportunity to cross a firth from one island to another. Even the tremendous firth in the islands of Maelstroom, on the coast of Norway, which at the time of the rising or falling of the tide, draws large vessels to a whirlpool where they are absorbed and lost, may at such times be crossed in safety.

As the depth of water in a harbour depends on the state of the tide, it is a matter of great importance to captains of ships to be able to tell at what hour it is high water, that on their arrival they may know whether there will be sufficient water to admit their vessels or not, that they may either attempt the harbour or keep off to sea away from the shore until the proper time. For this they have a very good rule. They find, by an easy calculation, what time the moon

comes to the meridian on that particular day, and as it is high water uniformly at a certain time after the moon passes the meridian, they add that time to the hour already found, and they have the hour of high water.

Thus suppose at Yarmouth they wish to know at what time it will be high water, and they have found the moon passes the meridian at three in the afternoon, as there it is always high water eight hours and a quarter after the moon passes the meridian, they know the time to be a quarter past 11.

As the moon at the time of new moon is on the meridian at mid-day, and at full moon is on the meridian at 12 at night, the hour of high water on those days is the time between the moon's passing the meridian and high water on any day. The above rule may, therefore, be stated, to add the time of high water on change days, to the time the moon comes to the meridian. There is in books of navigation a table of the time of high water on the days of new and full moon, and it is only necessary to

look out the place in the table to obtain that time.

It has been stated that the tide runs south when rising, and north when ebbing, on the east coast of Britain, and that it is not high water at all places at the same time. This will be best understood by the following table of the time of high water at different places on the east coast of England, on the days of new and full moon:—

Berwick	$2\frac{1}{2}$ hours, P.M.
Mouth of the Tyne . .	$3\frac{1}{2}$
Scarborough	$4\frac{1}{2}$
Dudgeon Lights	$7\frac{1}{2}$
Yarmouth	$8\frac{1}{4}$
Southwold	9
Orfordness	$10\frac{1}{2}$
North Foreland	$11\frac{3}{4}$

Thus it appears that the vast flood, which strikes upon the east coast of Britain, at high water, does not arrive in a line parallel to the coast, but strikes it obliquely, first coming in contact at the places farther north, and from a later and later time

coming upon the coast at places farther and farther south.

The same variety will be found on going east and west along the coast of the English Channel. This may be seen by the following table:—

Dover	11¼ hours.
Dungeness	10½
Shoreham	9¼
St. Alban's Head	7½
Torbay	6½
Eddystone Lighthouse .	5½
Lizard Point	5
Land's End	4½

The flood here enters the Channel, and makes it high water first at the Lizard, and later and later at places farther distant, and occupies nearly seven hours in reaching to Dover.

Such are some of the leading phenomena of the tides, and of which the causes were so long an object of inquiry.

Qua vi alta maria tumescant
Obicibus ruptis, rursusque in seipsa residant.
GEORGIC, Lib. ii. 479, 480.

The discovery of the doctrine of gravitation, enabled Sir Isaac Newton to find a solution in the attraction of the sun and moon, which is far from being without its difficulties, but explains most of the leading phenomena.

The spring-tides are at new and full moon; and high-water, in the open sea, is soon after the moon crosses the meridian. We see here the influence of this heavenly body, and as the earth revolves on her axis to the east, the moon comes on the meridian to places farther and farther west, and the swelling of the tide follows at a similar rate. The sun also has his influence, and this is seen in the effect of the united attractions of the moon and sun, at new moon, raising a spring tide.

The wave of tide is carried westward, from where it is drawn by the moon and sun, strikes against a line of coast; but instead of striking the whole front of the coast at once, it may come obliquely, and successively come in contact with the coast running on from north to south, and occasion high

[illegible]

The tendency of the [illegible] gravita-tion [illegible] the [illegible] not [illegible] the direction of the [illegible] being without [illegible] difficulties [illegible] of the [illegible] phenomena.

The [illegible] and [illegible] in the [illegible] the [illegible] We [illegible] the [illegible] the earth revolves [illegible] to the east. The [illegible] and [illegible] and the [illegible] of the [illegible] follows [illegible] its influence [illegible] the [illegible] of the [illegible] of the moon and sun, [illegible] a tide.

The [illegible] of tide [illegible] carried [illegible] by the moon and the [illegible]

water at successive hours, in the manner shown by examples taken from the coast of England. In the English Channel, the tide entering at the wide end, towards Cornwall, falls back from west to east, and occasions high water at successive hours, in the manner shown in the examples given.

In the Mediterranean sea there are scarcely any tides, there not being a rise of water above that of a few inches. Hence the bay of Naples appears at all times like a fine lake, and houses may there be built near the water side without having the disagreeable accompaniment of the exhalations which arise from the shore left dry by the tide. The old Romans were fond of laying the foundations of their houses in the sea, as is often referred to by Horace and other writers, and as may be seen by the ruins which still remain.

The Greeks, not being accustomed to tides, were much astonished when they were sent down the river Indus by Alexander the Great, and found the water rising and coming up the river, as they

conceived it contrary to the order of nature. They supposed it was the expression of the wrath of the Gods against their intended expedition; and it was not until they understood that it was a phenomenon of constant occurrence that their fears were dissipated.

The Romans were equally unacquainted with the nature of tides. When Julius Cæsar came over to Britain, the transports coming from Boulogne with the horse, instead of arriving at Dover, as they expected, were carried by the tide far out into the Channel. Also when Cæsar who had arrived at the time of neap tide had his ships drawn up on the beach, he supposed they were safe from the sea ; but there happening a storm, at the same time, with a spring tide a few days after, most of the vessels were damaged or broken to pieces. When the Romans by their navigation on the coast of Britain were more acquainted with the usual phenomena of tides, the sailors sent by Agricola to circumnavigate the island were completely perplexed with the tides and

[illegible] the Orkney islands [illegible] would appear from Tacitus that they [illegible] the motion of the sea itself to have [illegible] altered from that of a more [illegible]

There are no tides in the Baltic, nor in the Caspian Sea, or in general in [illegible] inland [illegible]

As the tides are produced by the attraction of the moon [illegible] it is not possible that there could be much difference [illegible] for the water to rise [illegible] all that can enter [illegible] by the straits of Gibraltar [illegible] very great difference [illegible] in the Mediterranean [illegible]

There are many phenomena [illegible]

currents between the Orkney islands ; and it would appear from Tacitus that they imagined the nature of the sea itself to have become altered from that of a more southern latitude.

There are no tides in the Baltic, or in the Caspian Sea, or in general in any inland lakes.

As the tides are occasioned by the attraction of the moon drawing the water of the ocean towards it, it is not possible that there could be much difference in the Mediterranean sea, for as there are only 6 hours for the water to rise from low to high water, all that can enter in the course of that time by the straits of Gibraltar cannot make any very great difference, and the quantity of water in the Mediterranean itself on account of its comparatively small extent and its shallowness, is not sufficient to rise a tide of above a few inches. The same cause accounts for the want of tides in the Baltic and other inland seas.

There are many phenomena attending the rise of the tides extremely irregular, and

which can scarcely as yet be brought to agree with any theory. There is yet much to be observed before all the different complicated causes of the motions of the waters, and their different effects can be properly ascertained.

The effects of the solar and lunar attraction, and of the centrifugal force, of the joint motion of the earth and moon, are extremely complicated, and their explanation can scarcely be brought within the plan of a popular elementary treatise on astronomy.

our attendant satellite.* The Pythagoreans, the most enlightened of the ancient sects as to natural science, could not contemplate the order of nature, imperfectly as it was then known, without being persuaded that there were other worlds besides our's.† In Greece, the men who most distinguished themselves by their discoveries, and whose names were held in the highest veneration, entertained the same ideas. Of these we may notice Anaximander, who, if he did not invent, at least greatly improved, the celestial globe. Anaximenes, his scholar, followed his opinions.‡ To these we may join Anaxagoras, Xenophanes, Leucippus, and Democritus.§ Plutarch has preserved a remarkable saying of Metrodorus, the disciple of Democritus, that there was not

* Plutarch. de Placit. Philosoph. Lib. ii. c. 13. Euseb. Prep. Evang. Lib. xv. c. 30. La Lande, Art. 302.

† Plutarch. de Placit. Philos. Lib. ii. c. 50.

‡ Stobæus, Ecl. Phys. Lib. ix.

§ Stobæus, Ecl. Phys. Lib. ix. Lactantius de Falsa Sapientia, Lib. iii. c. 23.

a greater absurdity in supposing there was only one blade of grass in a field, than in supposing there was but one world in infinite space. Lucretius, the celebrated poet, one of the Epicurean philosophers, after considerable length of argument to prove a plurality of worlds, thus infers:

" Quapropter, cœlum, simili ratione fatendum est,
" Terramque, et solem, lunam, mare, cætera quæ sunt,
" Non esse unica, sed numero magis innumerali."
De Rerum Natura, Lib. ii. 1083—1085.

Which is thus rendered by Creech:

" It plainly follows, that there must arise
" Distinct and numerous worlds, earth, men, and skies,
" In places distant and remote from this."

Seneca informs us, that some of the Stoic philosophers were even so bold as to believe the sun himself a habitable body.* It is not, perhaps, straining the sense of the sacred text, to infer, that the writer of the Epistle to the Hebrews was acquainted

* Lactantius, de Falsa Sapientia, Lib. iii. c. 23.

with the idea of a plurality of worlds.—"Through faith," says he, "we understand that the *worlds* were formed by the word of God."*

On the revival of learning, when Astronomy and the other sciences began to be cultivated, after the long dreary night of darkness, which had overshadowed Europe during the middle ages, we find the idea of a plurality of worlds patronised by Copernicus, Tycho Brahe, Kepler, Galileo, Revelius, Des Cartes, and many others. It is now so generally received, that not to entertain it would be a singularity.

We now proceed to show, that the proofs are numerous and satisfactory. They may be arranged in three parts:

I. The immense distance, size, and number of the heavenly bodies, render it impossible to be believed, that they were created for the sake of our earth.

II. The more we find out respecting the heavenly bodies, the more clearly do we

* Hebrews, xi. 3.

perceive them capable of comfortably maintaining inhabitants.

III. From a survey of our own globe, which we find every where abounding in animal life, we are led, by analogy, and the uniformity we discover in the designs of nature, to believe the same to be the case in other parts of the creation.

We shall first take notice of the immense distance, size, and number of the heavenly bodies.

We are accustomed to speak of the planets, as being so many millions of miles distant from the sun, whilst we have but a very imperfect conception of the idea in our minds. Thus we say, in round numbers, the earth is 96,000,000 miles distant; and this we do familiarly enough, whilst our imaginations are totally unable to comprehend what we express. Let us call in a little arithmetic to our assistance, and calculate how long time it would require to travel this distance, going at the rate of 100 miles a day. In a year of 365 days 6 hours, 36,525 miles will have been gone

over. If we divide 96,000,000 by this number, we shall have for the quotient about 2600, which is the number of years it would require, going at the rate of 100 miles a day, to reach the sun. In the whole time, therefore, which has elapsed since the birth of our Saviour, only two-thirds of the distance could have been passed over.

Yet this great distance of our earth from the sun, of which such considerations give us some idea, is only the nineteenth part of that of one of the sister planets that revolve round our sun; and when it is compared with the distance of the nearest of the fixed stars, is but an imperceptible point. From the most accurate observations, made with the best instruments, by the most skilful astronomers, it has never been discovered that the earth had any annual parallax, or, in other words, that the whole diameter of the orbit, immense as it is, bore the smallest perceptible proportion to the distance of the stars. Dr. Bradley calculated that a star he observed in Draco, was at least 400,000 times as far off as the distance of

[illegible] this [illegible] we shall have for the [illegible] which is the number of years [illegible] giving [illegible] to reach the sun. In the whole time therefore which has elapsed since the birth of our Saviour, only two-thirds of the distance would have been passed over.

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the earth from the sun. It must therefore be at least 38,400,000,000,000 miles. To reach this star, then, at the rate of 100 miles a day, would require 1,050,000,000 years : so that a body moving at that rate, ever since the creation, which according to the best chronological system, taken from the Septuagint, is rather more than 7000 years, would only have got about the 150,000th part of the way.

Let us now attend to the size of the heavenly bodies. The planet Jupiter is 1600 times as large as our earth. The sun is no less than 1,400,000 times as large. The fixed stars, which shine with their own light, and are therefore so many suns, are probably as large, and some may be larger. If we reflect how small our sun appears to us, though so large a body, we must be convinced that the stars are of immense size, in order to be seen by us at all, since they are at a distance, compared with which that of the sun is but as nothing.

The number of the stars is equally amazing with their distance and size. Dr. Her-

schel reckoned, that about 116,000 passed over the disk of his telescope in about a quarter of an hour. How immensely numerous, then, they must be! La Lande reckons them at 75,000,000.* If, therefore, our sun, with all his attendant planets, and a thousand stars besides, as large as he, were to vanish away, they would not be missed in the vastness of creation.

We may now ask, Is it possible to believe that these orbs, so numerous, so vast, so widely scattered in the boundless expanse of space, should have been created for the sake of our earth, which is scarcely a grain of sand in comparison? The idea is absurd, and cannot be admitted. If not made, then, for the sake of our earth, there can be little reason to doubt, since the Creator does nothing in vain, and all nature is full of his goodness, that they were formed for the sake of their own inhabitants.

* Memoirs of the Academy at Dijon, 1785. Greig. Astrography.

"For such vast room in nature unpossess'd
"By living soul, desert and desolate,
"Only to shine, yet scarce to contribute
"Each orb a glimpse of light, conveyed so far
"Down to this habitable, which returns
"Light back to them, is obvious to dispute."
PAR. LOST, viii. 152—157.

II. The more we find out respecting the heavenly bodies, the more clearly do we perceive them capable of comfortably maintaining inhabitants.

By the benevolent wisdom of the Creator, our own earth, by a diurnal revolution on its axis, brings us the grateful vicissitude of day and night. When men, and the inferior animals, have become wearied by the toils of the day, nature kindly draws the curtain of darkness around them, and invites them to a friendly repose. The same motion by which this grateful effect is produced is discovered in the planetary bodies. Of the diurnal motions of Venus, Mars, Jupiter, and Saturn, we are fully certain, and we have no reason for doubting it of the rest. Like our earth, the planets revolve round the

sun, and some of them, by the inclination of the axis to the orbit, give a variety of seasons. There are also in the planets, different degrees of temperature, from the heat of their equator to the cold of their poles, adapted, as in our earth, for different animals and vegetable productions.

A most striking proof of the planets being inhabited, arises from the evident care which the Creator has shown to furnish them with light. Our earth is attended by one luminary, the Moon, which supplies the place of the sun, and is of particular service to us in winter. For at that season, the full moon is in the same part of the heavens that the sun is in during summer, and consequently continues longer above the horizon, in the same proportion as the day in summer exceeds that in winter. That the planet Venus has a satellite we are not certain. Mars is so small, that if he has got one, we cannot, with our best instruments expect to see it. But, with regard to the far distant Jupiter, we find a noble attendance of no less than four moons, some

of them larger perhaps than our earth, and revolving rapidly round him. We cannot suppose these secondaries to have been made for any other purpose than for illuminating the inhabitants of that vast orb. For though, since the discovery of the telescope, and improvements in Astronomy, they have been of service in determining the longitude, they are at such a distance from us, that with the naked eye, they never could be seen ; and it is but a few years, comparatively, that their existence has been known on our earth. It is particularly worthy of our notice, that in proportion as the planets recede from the sun, so much the more care is taken by the Creator to supply them with light by means of secondaries. Saturn, much more distant than Jupiter, has seven moons, besides a luminous ring. Herschel, which is but a late discovery, is already known to have no less than six attendant luminaries.

Some of the planetary bodies are known to have an atmosphere ; and they all may, though we cannot prove it. Where there

is an atmosphere, we may, without difficulty, believe there are living creatures, who support life by breathing it.

With regard to the surfaces, the planets are too remote for us to make any minute observations. The only body sufficiently near is,

> "the Moon, whose orb,
> "Through optic glass, the Tuscan artist views
> "At evening from the top of Fesole,
> "Or in Valdarno, to descry new lands,
> "Rivers, or mountains, in her spotty globe."
>
> Par. Lost, i. 287.

Her surface greatly resembles that of our earth, and seems equally well adapted for being inhabited.

Since we find the planets thus well adapted, as far as we have been able to discover, we have no reason to stop short in our belief, but have a right to suppose they are so in other respects. It is an undisputed principle in Newtonian philosophy, that those properties which are found to belong to all bodies within our reach, are to be

considered as the universal qualities of all bodies whatsoever. If we apply this rule of analogy to our present subject, we may fairly believe, that as the solar system is well accommodated for being inhabited, the same is the case with the innumerable systems throughout the universe.

There may, no doubt, some difficulties be started in opposition to our believing the solar system inhabited; but it is very likely that a superior acquaintance with the laws of nature would completely dispel them. Before the simple doctrine of attraction was understood, it was the utmost effort of philosophic faith, to believe in the existence of the antipodes on our earth. Herodotus sneers at the idea of the earth being round. Plutarch informs us, that Lucius, a celebrated ancient philosopher, ridiculed the idea, by comparing the antipodes on the opposite side of our earth, to cats hanging by their claws.* Plutarch himself did not believe in their existence.

* De Placit. Philosoph.

Lucretius endeavours, at some length, to prove the utter impossibility.* Even in the age of Constantine the Great, the learned Lactantius, the Cicero of those days, speaks of the doctrine in terms of contempt, and opposes it by arguments he, no doubt thought of great weight. "What shall we "think," says he, "of them who assert that "there are antipodes opposite to our feet? "Can any one be foolish enough to believe "that there are men, whose feet are higher "than their heads? Or, that those things, "which with us lie on the ground, there "hang? That corn and trees grow down-"wards? That rain, snow, and hail, fall "upwards towards the earth? How "strange is it that the hanging gardens of "Babylon were reckoned among the won-"ders of the world, when philosophers can "make hanging fields, and seas, and "cities, and mountains! I could prove," says he, a little farther on, "that it is alto-"gether impossible that there should be

* Lib. i.

"heavens below the earth, were it not that "I must now conclude this book."* The same side of the question is taken by St. Augustine, a century after.† It is unnecessary to take notice of the persecutors of Galileo, who have gained themselves a name which is little to be envied.

The objections to the solar system being inhabited, are probably not better founded than those against the existence of the antipodes. However, we may notice the most plausible, which is, that the inferior planets, Mercury and Venus, being so much nearer to the sun than our earth, must be too hot; and that the superior planets, being so far off, must be too cold. We cannot be too cautious in the estimation we form of the degree of heat and cold in which an animal body may thrive. The ancients were fully persuaded, that the torrid zone of our earth, lying under a vertical sun, must be burnt up with the

* De Falsa Sapientia, Lib. iii. c. 24.

† De Civitate Dei, Lib. xvi. c. 9.

heat; and they also believed, that the two frigid zones were for ever bound in ice, and consequently, in both cases, there could be no inhabitants. Nothing is more false. Nature adapts the constitution of the inhabitants to every variety of climate. The Greenlander finds comfort amidst his icy cliffs, and the African under the scorching rays of a vertical sun.

The reindeer and the polar bear find pleasure in dwelling amidst the snow, and the camels in the dry parched desert.—Nature in like manner is fully capable of adapting the constitutions of the planetary inhabitants to the temperature which may prevail.

The temperature may also be modified in a variety of ways, besides distance from the sun. The heat originally given by the creator to the planets near the sun may have been small, and that to the distant planets may have been great, and although more heat may be received now from the sun at Mercury and Venus, than at Jupiter and Saturn, the mean temperature of the latter

may still be much higher. The heat receiv-ed at the equator of the nearer planets may by their atmosphere be carried off towards their poles, and equalised over the whole of their surface. The density or rarity of the atmosphere has a great influence. From this cause, we have on our earth, even under the equator, every possible variety of climate. On the low plains there is a scorching heat. It becomes milder as we ascend. In the wide-extended upland plains of Mexico and Peru, the excessive heat usually experienced in the torrid zone, is totally unknown.* Around Quito (lat. 0° 13,) eternal spring and autumn go hand in hand; the exact climate which poetic fiction has ascribed to the golden age.—Fruits and blossoms are on the same tree, men are seen sowing and reaping in adja-cent fields. Higher up, where the air be-comes still more rare, are seen the hoary summits of the mountains clad in eternal

* Humbold's Political Essay on New Spain.—Ulloa's Voyage.

snow. Thus, by ascending a mountain in the torrid zone, from the single circumstance of the air becoming rarer, we have every variety of climate, with all its corresponding vegetables, that is to be met with in passing from Guinea to Nova Zembla. How easy is it, therefore, for nature to render the climate of the planets suitable for inhabitants.

Seeing, then, the planets are in so many respects so evidently well adapted for the use of rational inhabitants, and no objection of any weight can be brought against the opinion, we may justly infer, that the Creator has not exerted his power and wisdom in vain, but that there, there are object of his bounty, who, like us, partake of his goodness.

III. We shall be led to a similar conclusion by our third train of argument, which was, that, from a survey of our own globe, which we find every where abounding in animal life, we are led by analogy, and the uniformity which we discover in the designs of nature, to believe the same to be the case in other parts of the creation.

worse. Thus, by [illegible] a thousandth in [illegible] the single [illegible] of [illegible] we have [illegible] of climate, [illegible] that is to [illegible] Nova Zembla. [illegible] of the planet's [illegible]

Seeing, then, the planets [illegible]

[illegible]

Man we find all over the face of the globe, from the equator, to far within the regions of ice and snow. For even Iceland, Greenland, Norwegian Lapland, and Nova Zembla, have their inhabitants and admirers, who would not leave them for any fairer land.

> " The shudd'ring tenant of the frigid zone,
> " Boldly proclaims that happiest spot his own ;
> " Extols the treasures of his stormy seas,
> " And his long nights of revelry and ease."
>
> GOLDSMITH'S *Traveller*.

Inferior animals are also found in every clime. The white fox *(canis lagopus)*, the polar bear *(ursus maritimus)*, and the reindeer, delight in the frozen regions of the north, and dread a southern sun. In the hot tropical climes, the lion and the tiger roam the tyrannic sovereigns of the forests; whilst the elephant and rhinoceros, secure in native strength, in the shady plains peacefully feast on the vegetable produce of the earth. In the same regions, troops of the monkey tribe sport from tree to tree. The

places least likely have their inhabitants. The camel and wild ass dwell in the desert; the chamois and rock goat love the Alpine heights; whilst the lama delights in the snowy ridges of the Cordilleras. No part of the world is left untenanted by nature. New Holland and America present genera and species peculiarly their own. As to the feathered creation, whether in the waters or on the land, on the plains or on the mountains, in the desert or the forest, from Greenland to Cape Horn, we find innumerable flocks of varied size and plumage. The serpent tribe, and other amphibious animals, abound even in countries where the rigour of winter subjects them to a torpor of many months. The ocean swarms with inhabitants in every clime. Shoals, more numerous than the sand on the shore, roam from coast to coast.

Perhaps the insect tribes show, most clearly of all, the intention of nature to leave no void unoccupied with animal life. Who can count the millions which, in every land, and particularly in those little occupied

by man, flutter with active wing, and fill up the little sphere of their existence. Almost every leaf is an inhabited world. If we call in to the assistance of our organs of sight the powers of the microscope, vitality multiplies before us, to an extent that at once amazes and confounds. A drop of water often contains many thousands: nay, we are told on good authority, that in some fluids, there are "animals so small, that 3,000,000,000 of them are not equal to a grain of sand."* We thus perceive that the power of the Creator is equally beyond our comprehension, in small things as in great.

If we thus find creation, within the sphere of our researches, to teem with vitality, can we suppose it to be otherwise in places beyond our reach? The uniform design of nature, pursued in such a vast variety of circumstances and means, in our globe, affords us ample reason to believe it is extended to other worlds also. We cannot hesi-

* Keill's Anatomy.

tate to believe, that realms so vast, and innumerable as the sand, scattered throughout the boundless regions of space, are tenanted by rational beings like ourselves.— To suppose otherwise, would be to impeach the wisdom of our Maker. An inspired prophet ascribes glory to God, that he formed the earth, and created it not in vain, but to be inhabited.* We may apply the same reasoning to the universe in general, and believe, that throughout immense space where the wisdom and power of God are so evidently manifested, there too his goodness is exerted on objects capable of enjoying it.

* Isaiah, xiv. 18.

THE END.

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