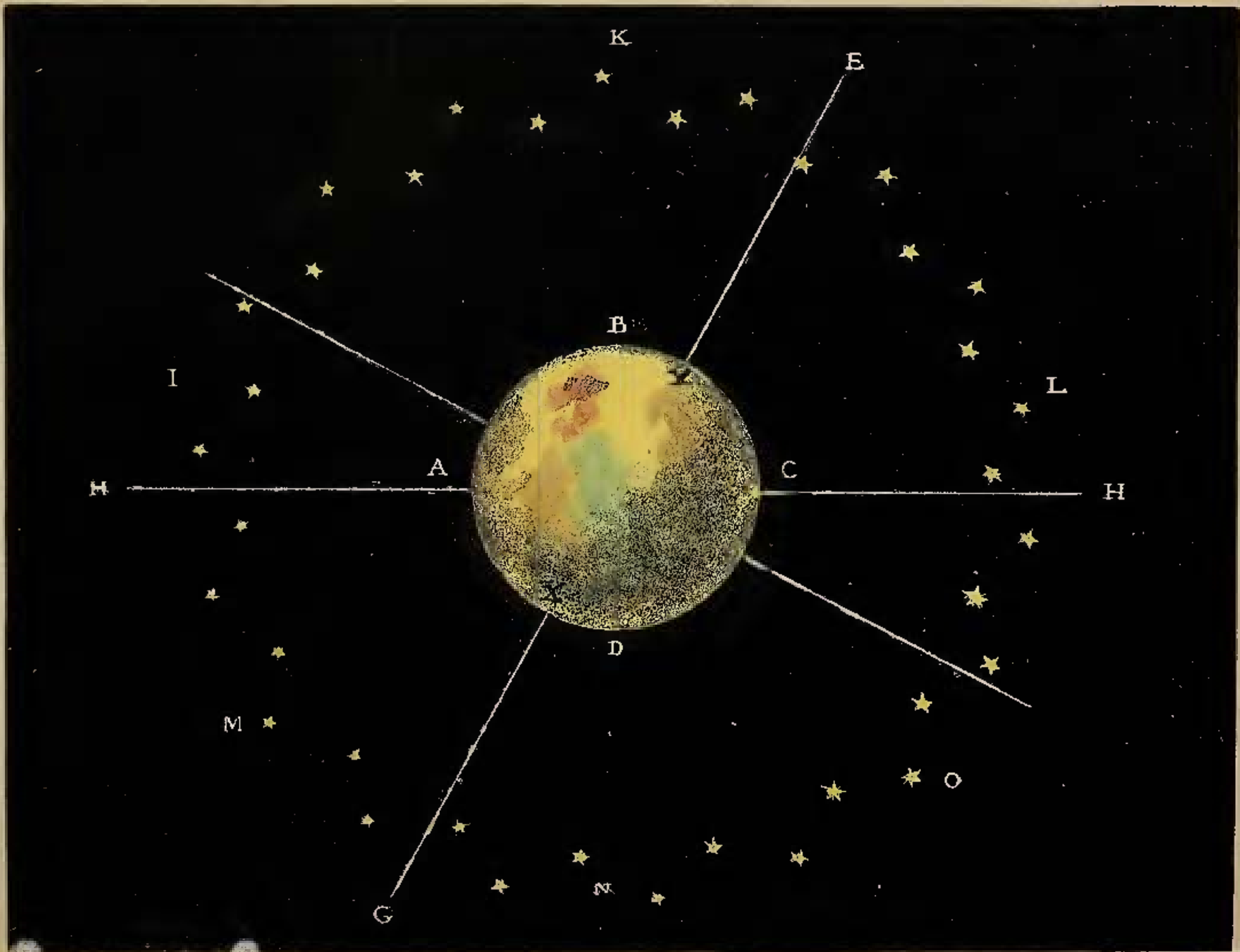
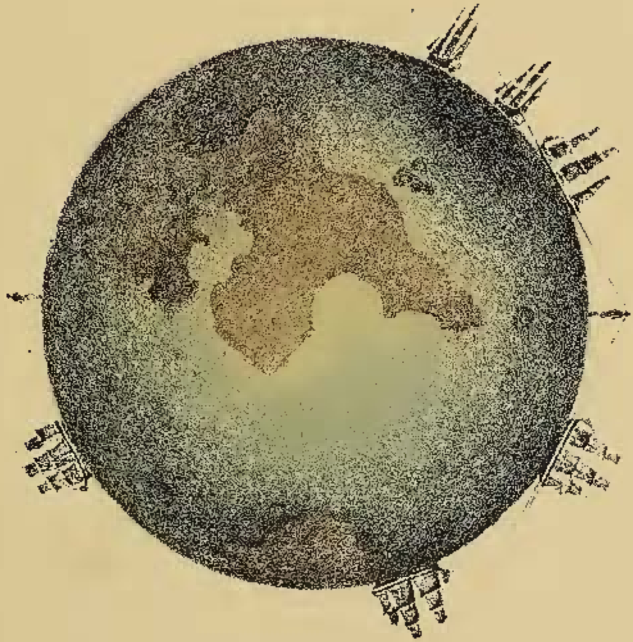
THE BEAUTY OF THE HEAVENS

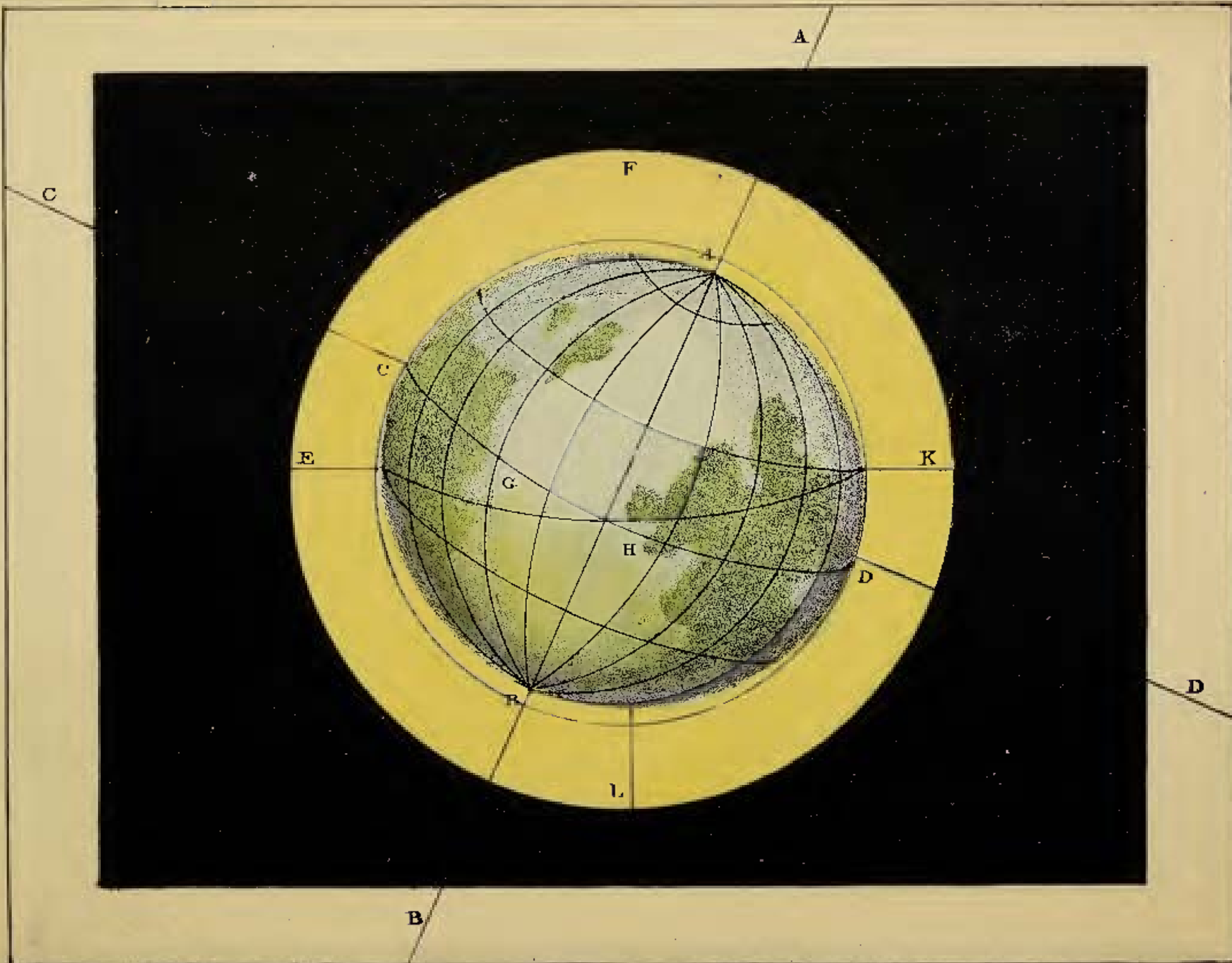
-250-

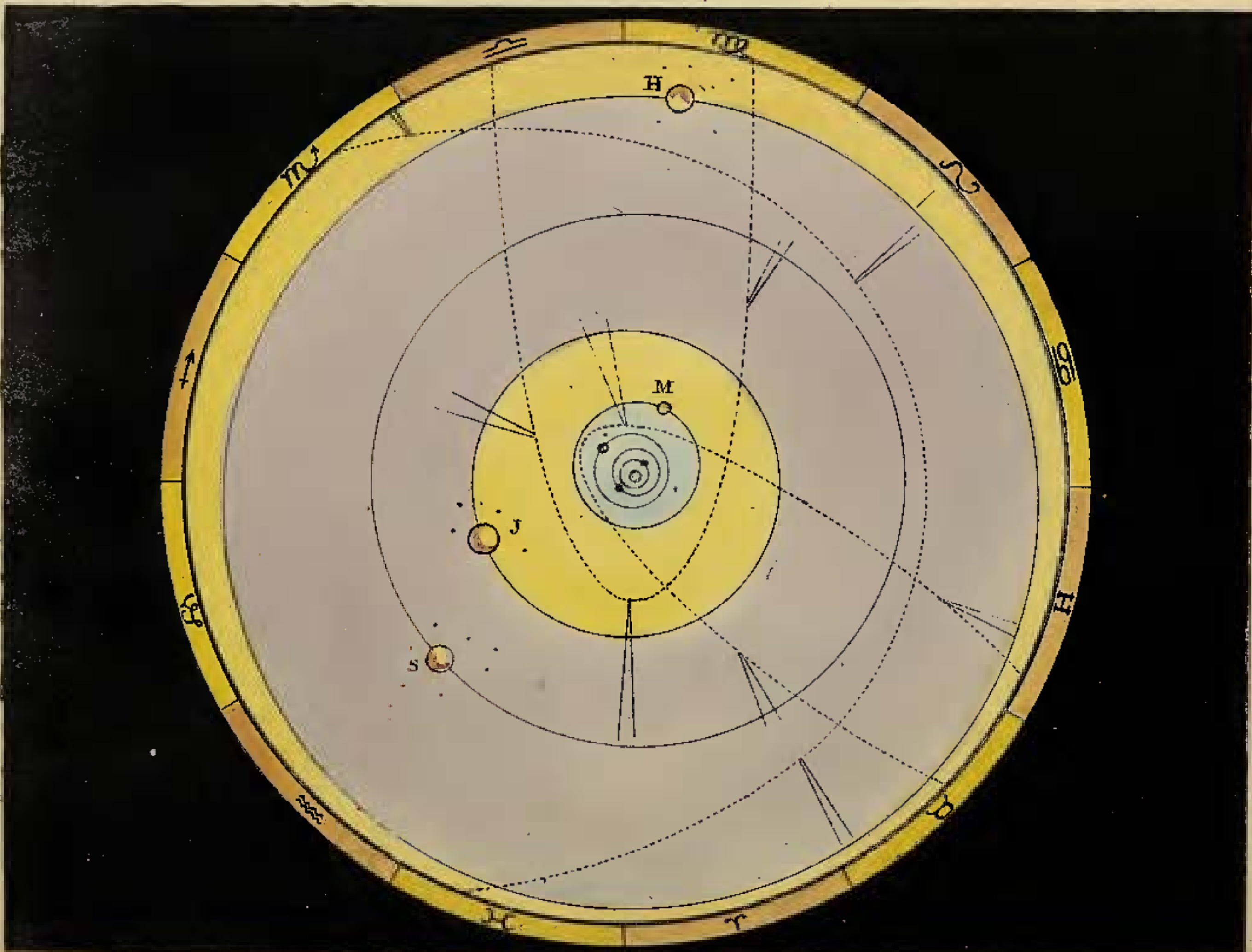
THE

BEAUTY OF THE HEAVENS.

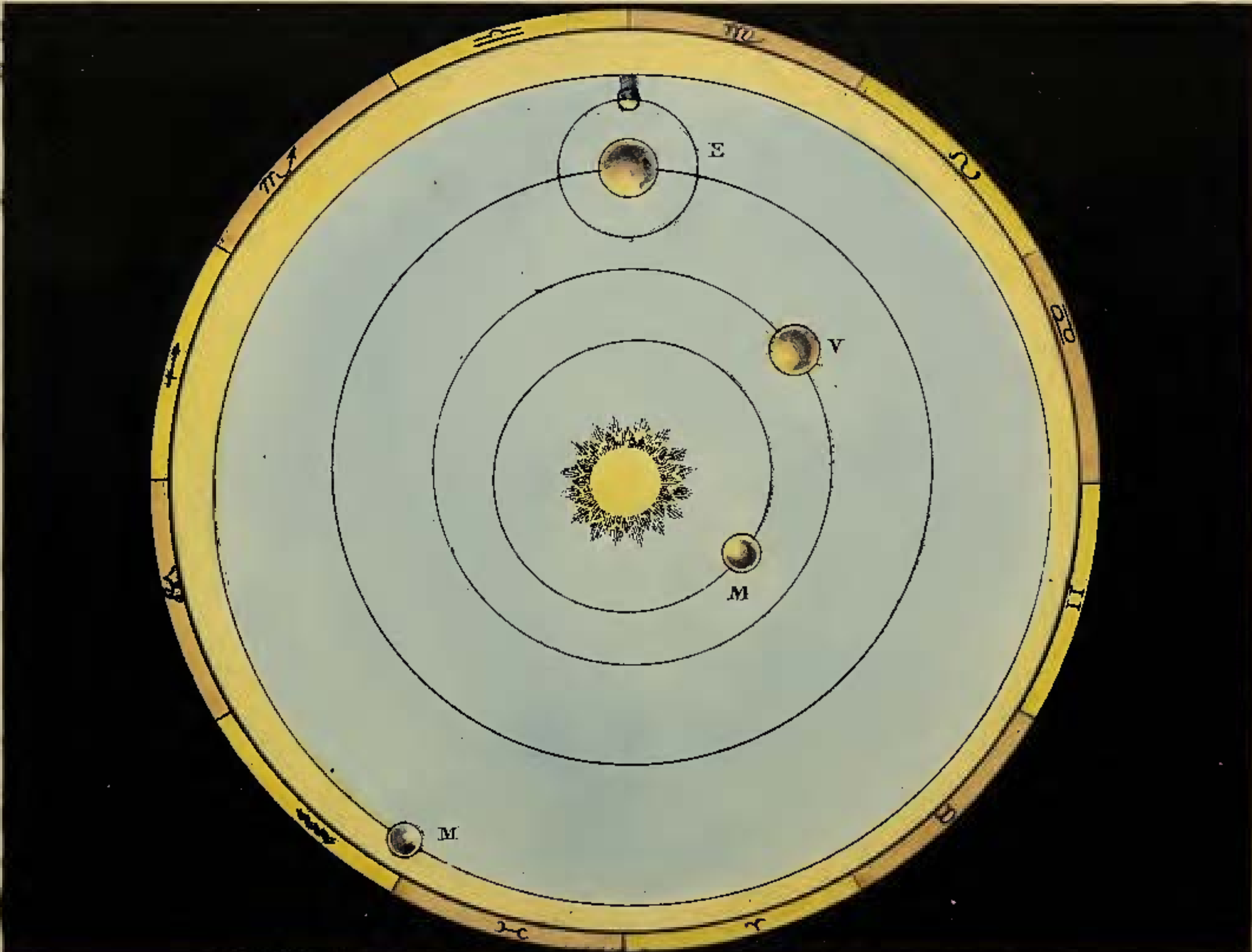

K
E
B
I
L
A
C
H
H
D
M
O
N
G



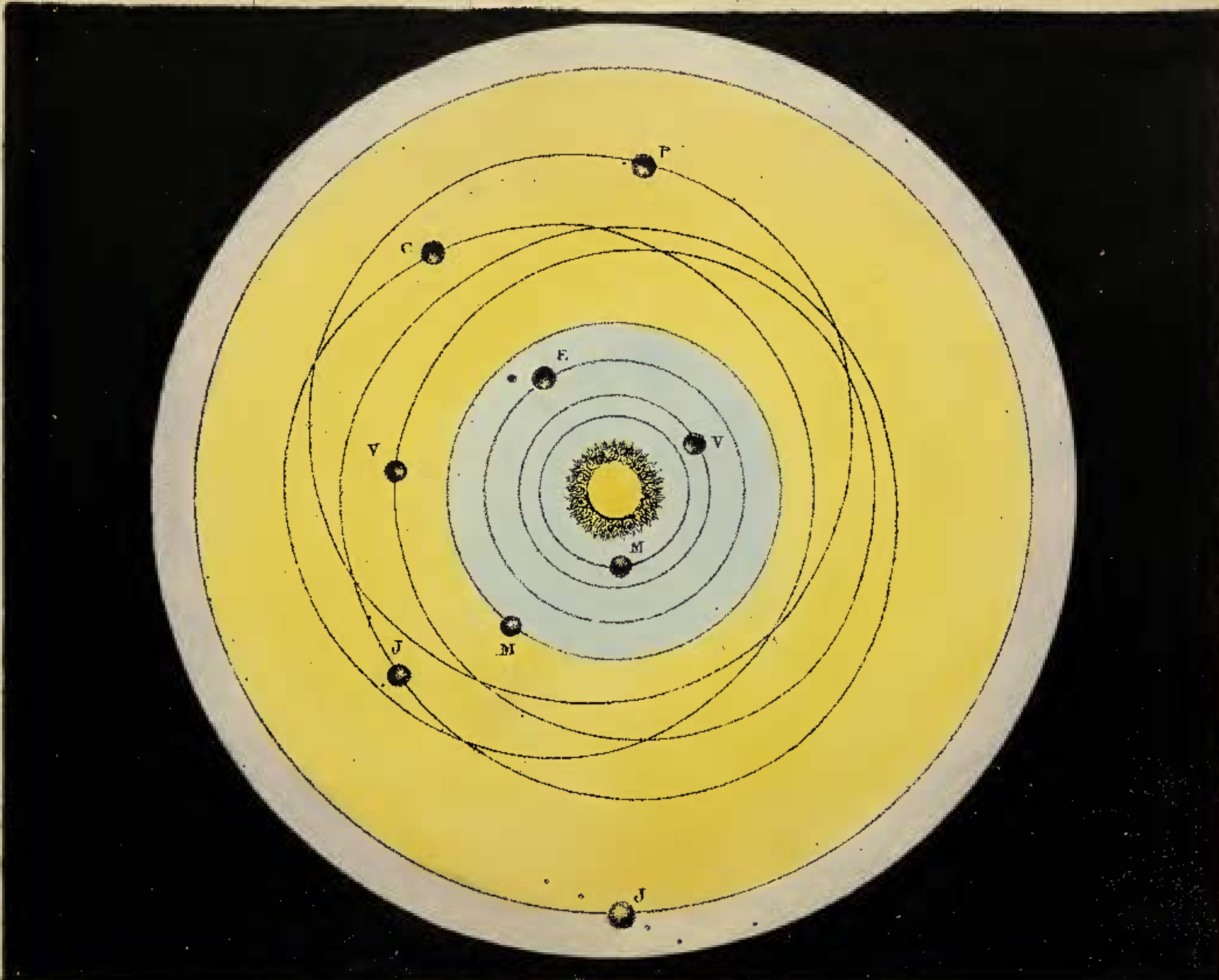

A
C
F
C
E
K
G
H
D
D
R
L
B



No. 4. THE PLANETARY SYSTEM.



N°5. MERCURY_VENUS. THE EARTH_MARS.



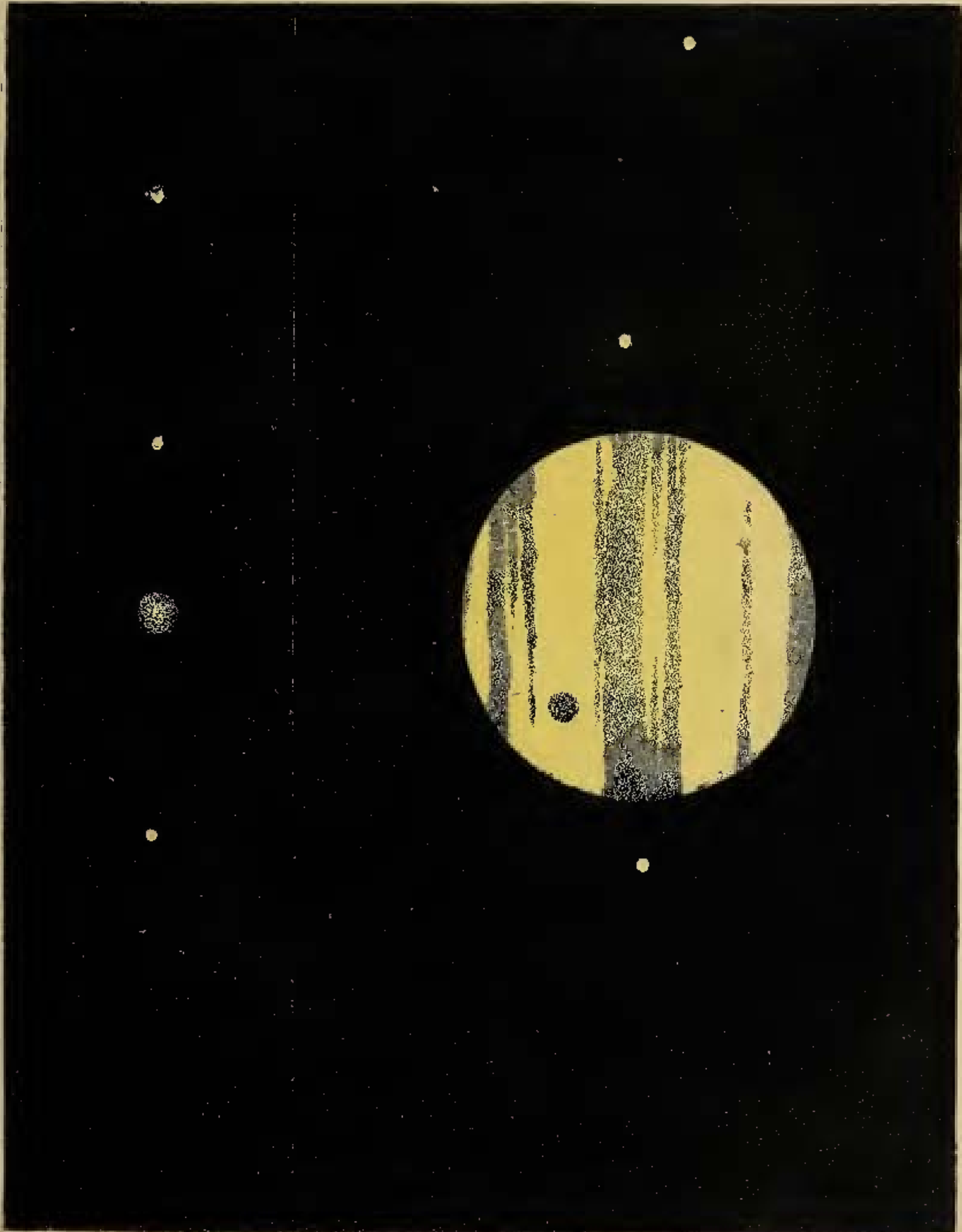
No. 6. THE EARTH, INFERIOR PLANETS AND ASTEROIDS.

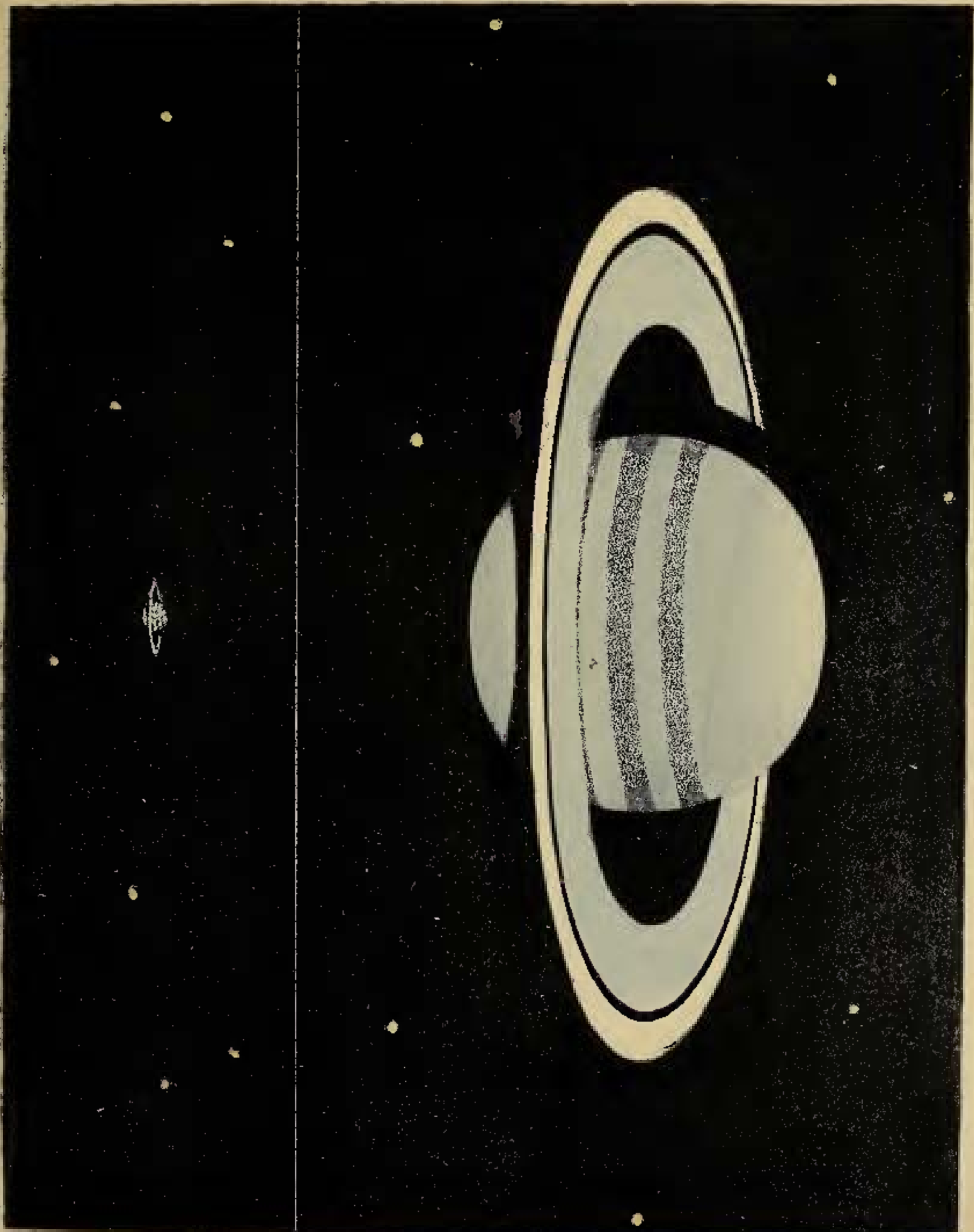
No. 7. THE SUN'S DISC.

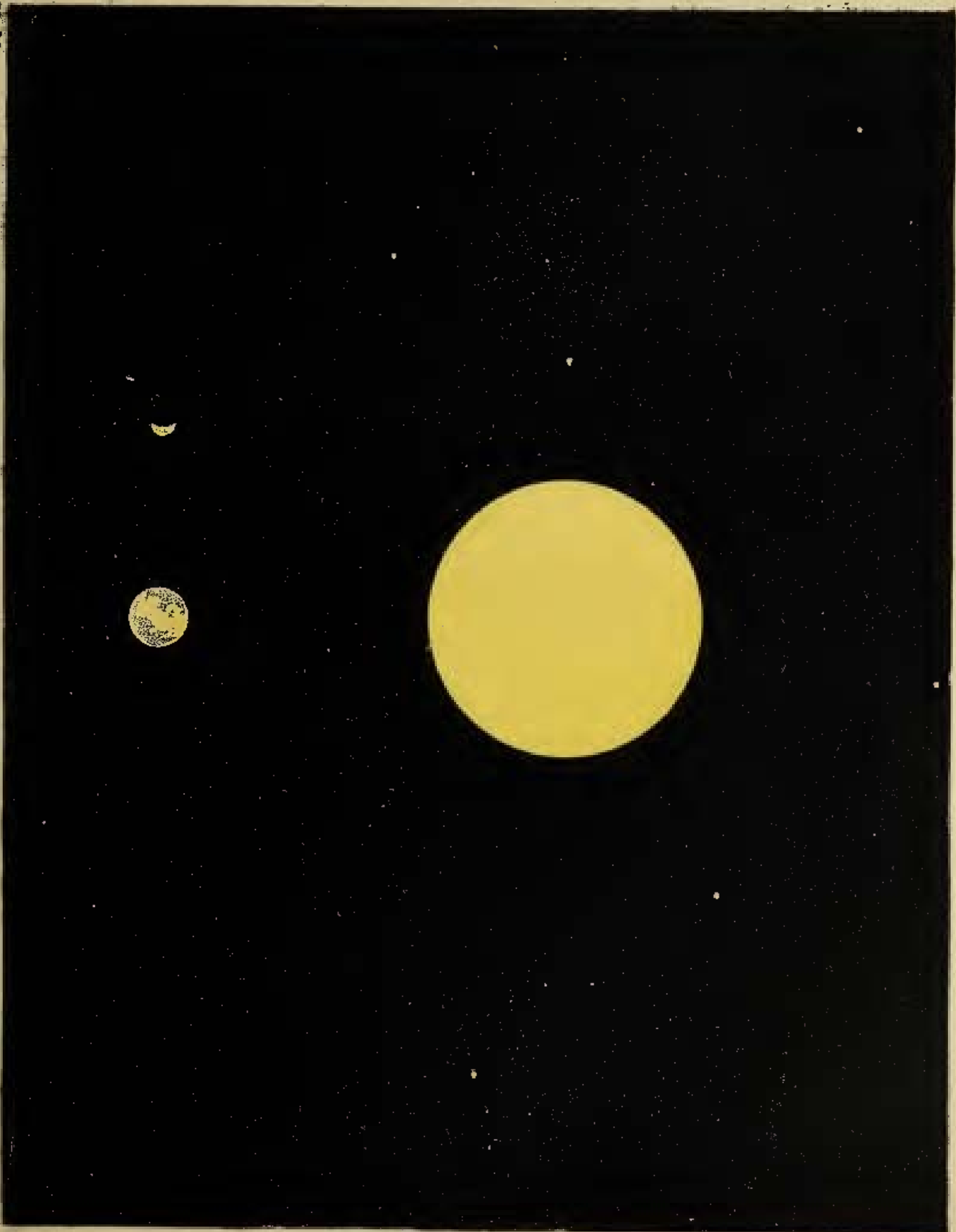
No. 8.

THE PLANET VENUS.

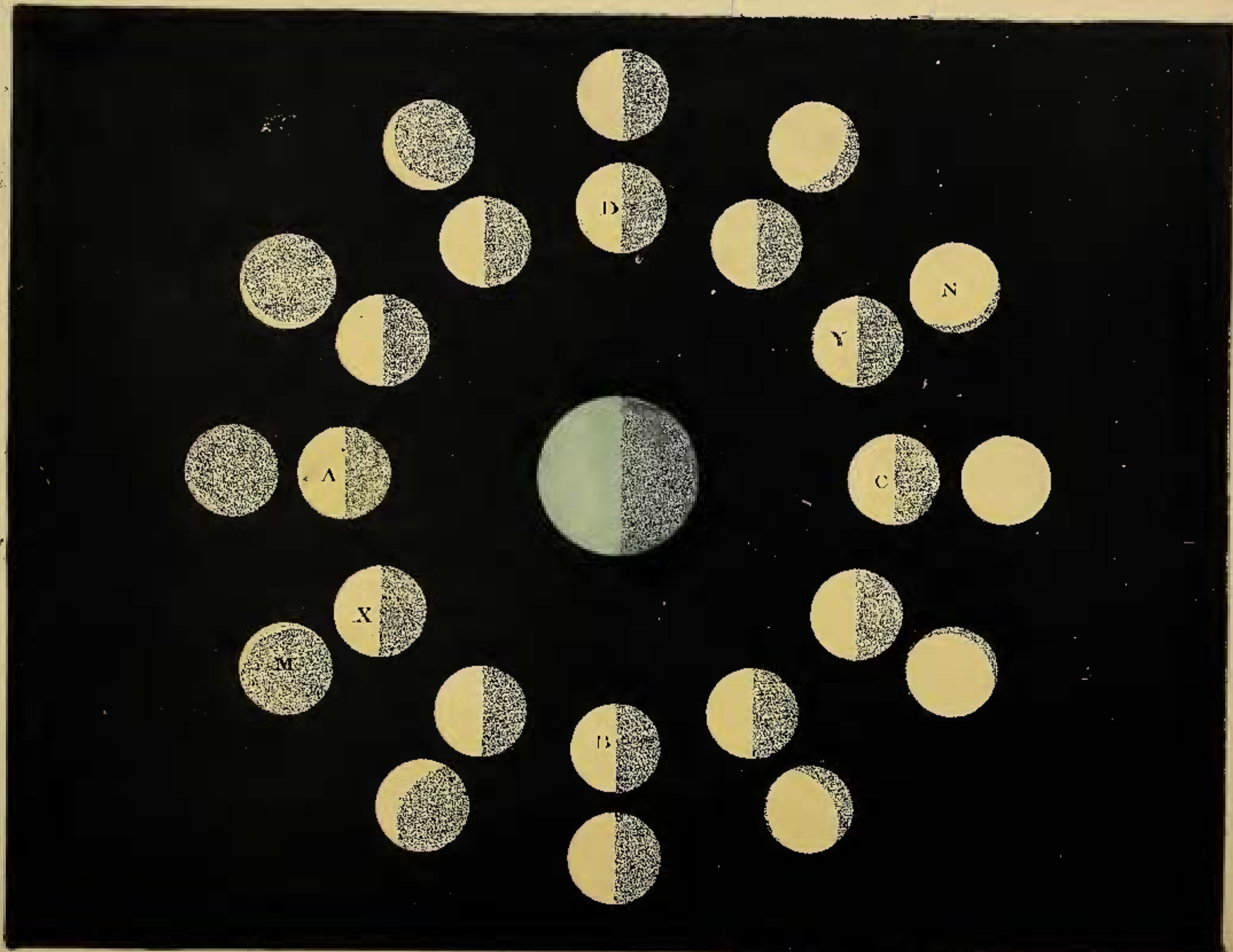
N^o. 5 THE PLANET MARS.



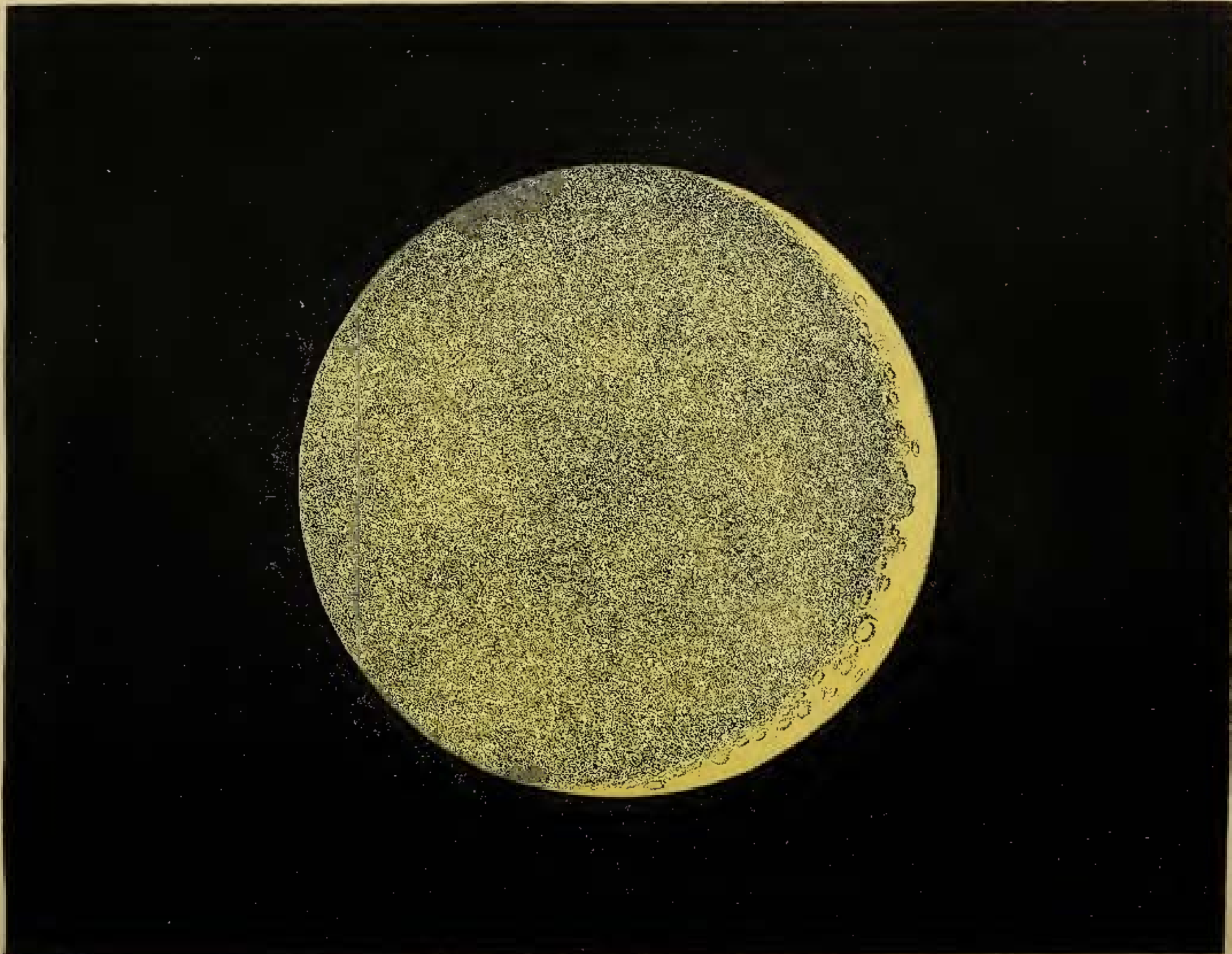




No. 14. THE NOMENCLATURE OF THE LUNAR SPOTS.



No. 15. THE MOON'S PHASES.



N° 16. THE CRESCENT MOON. N° 1

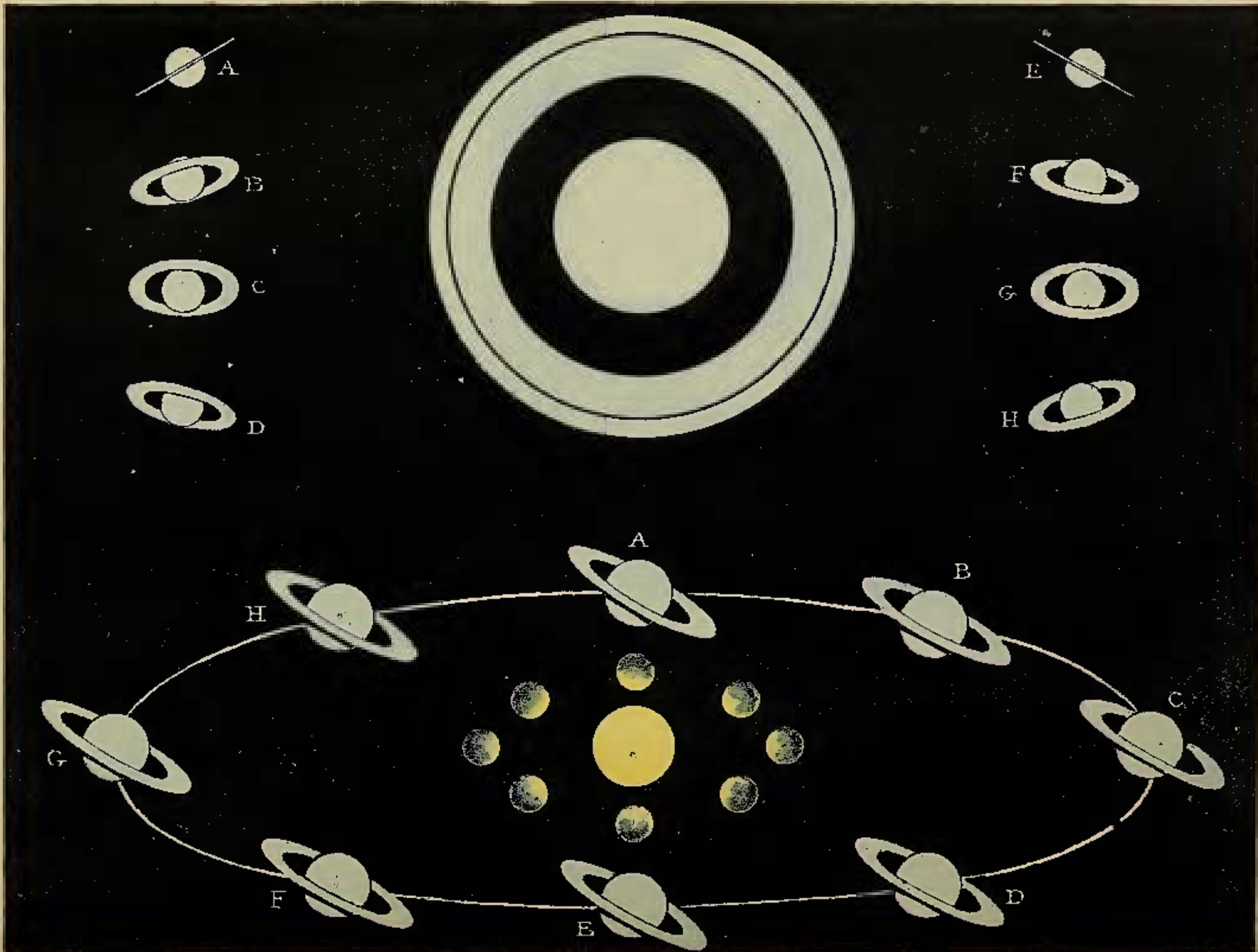
No 17

N°18

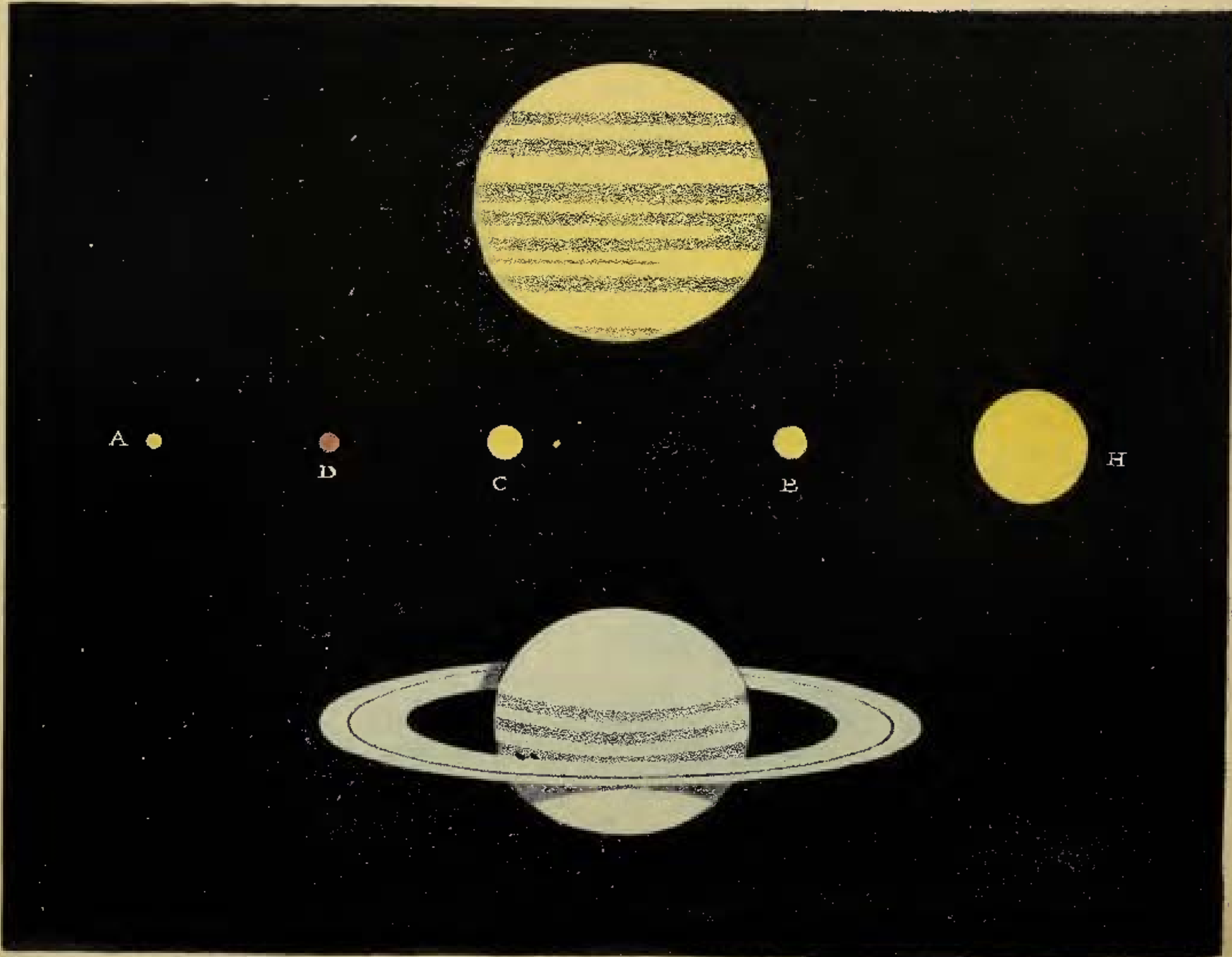
THE MOON GIBBOUS.

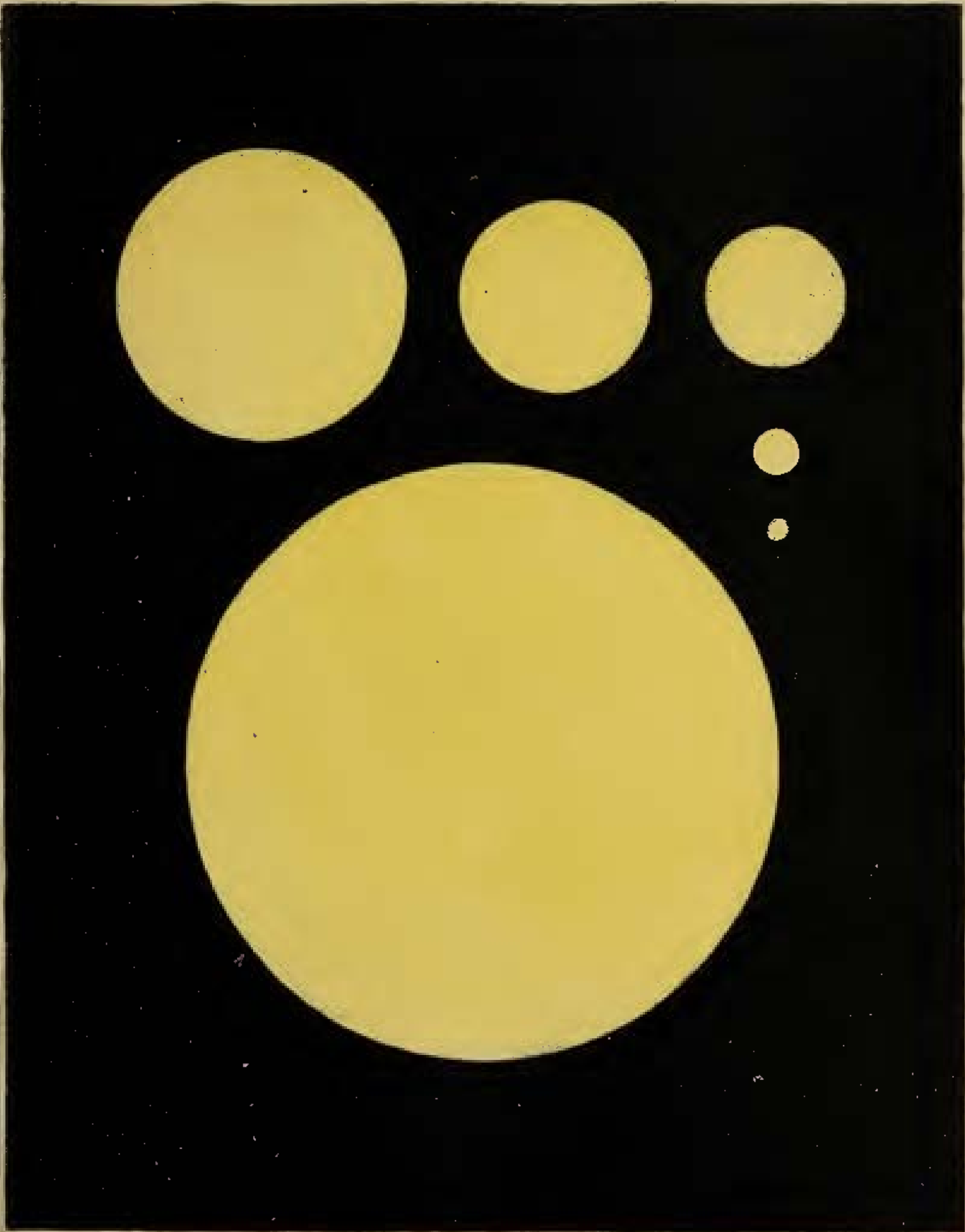
No. 19.

THE WANING MOON.



Nº 20. PHASES OF THE PLANET SATURN.


A
D
C
B
H



No. 23. CONSTELLATIONS OF THE NORTHERN HEMISPHERE

N° 25.

DRACO _ URSA MINOR.

LYNX.

No 27.

AURIGA

Nº 28.

PERSEUS

No 29

ANDROMEDA.

No. 30

CASSIOPEIA.

No. 31. PEGASUS.

CYGNUS and LYRA

N°33.

CEPHEUS.

No. 34.

HERCULES

Nº 36.

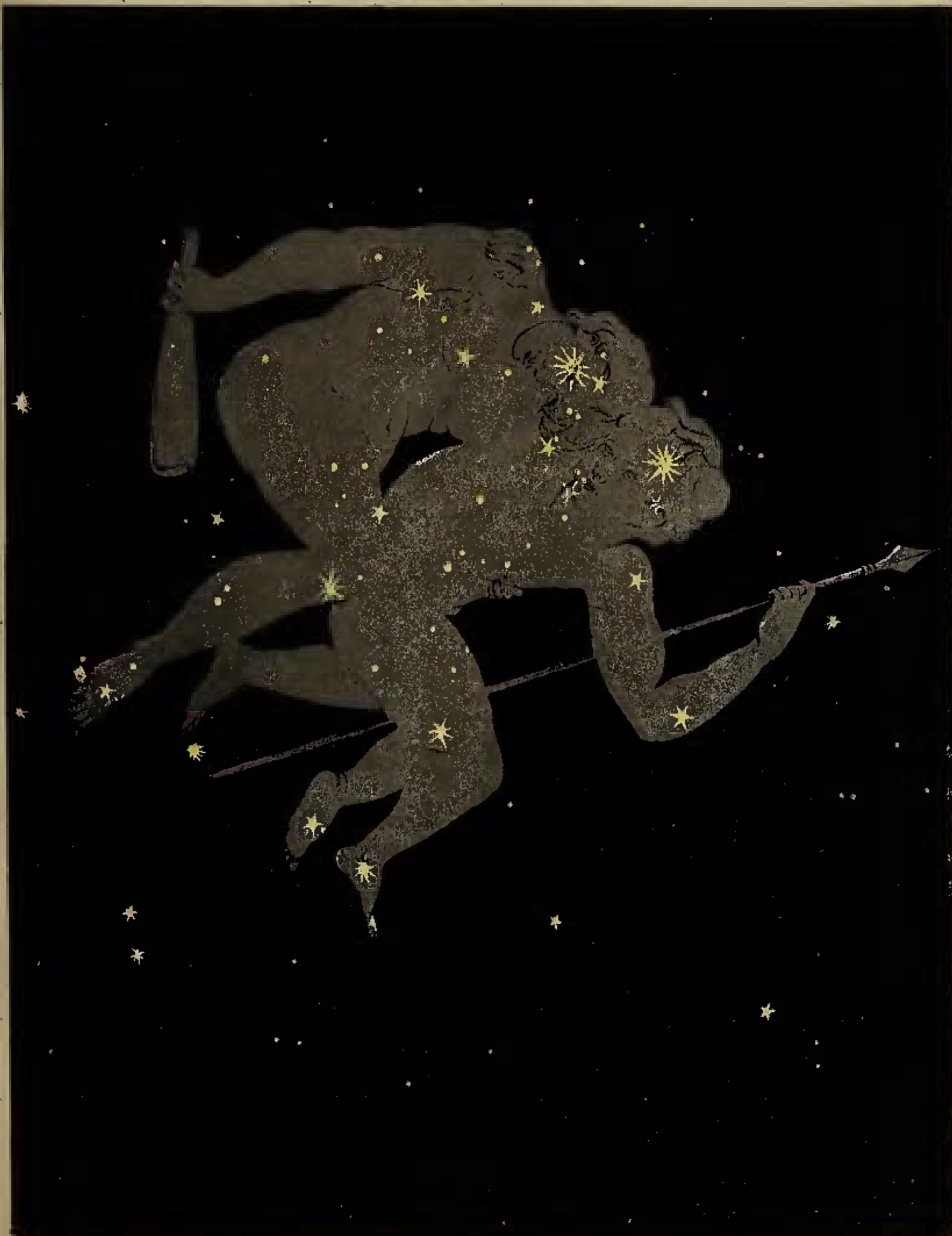
BOOTES.

N° 36.

OPHIUCUS.

Nº 27.

AQUILA & ANTINOUS.



N°40

GEMINI.

No. 41

CANCER.

No. 42. LEO.

N:45.

VIRGO.

No. 14

LIBRA

No. 45.

SCORPIO.

N°46.

SAGITTARIUS.

No. 47.

CAPRICORNUS.

N.º 48.

AQUARIUS.

N°49.　　PISCES.

Nº 50

MONOCEROS AND CANIS MINOR.

No. 51.

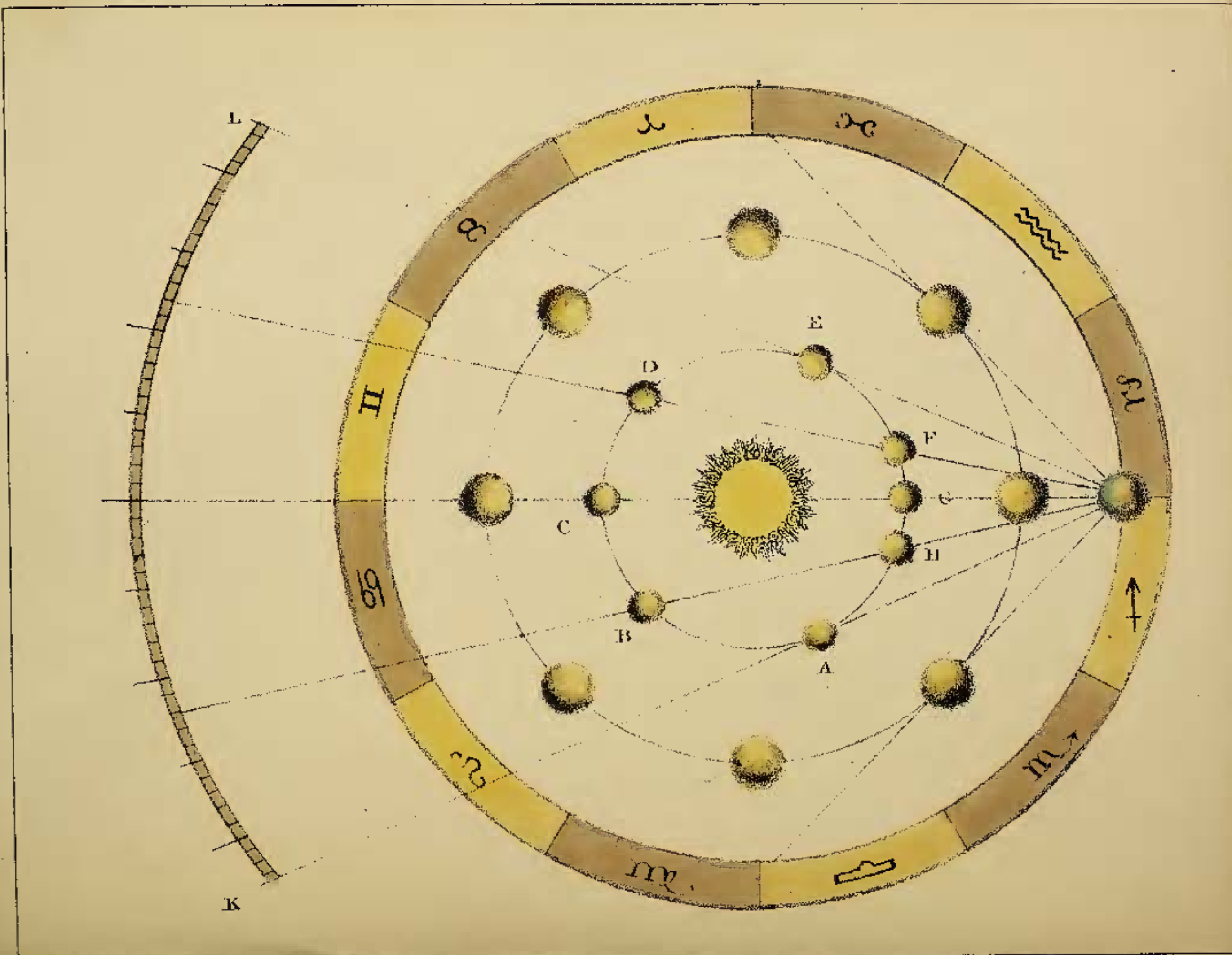
CANIS MAJOR

52

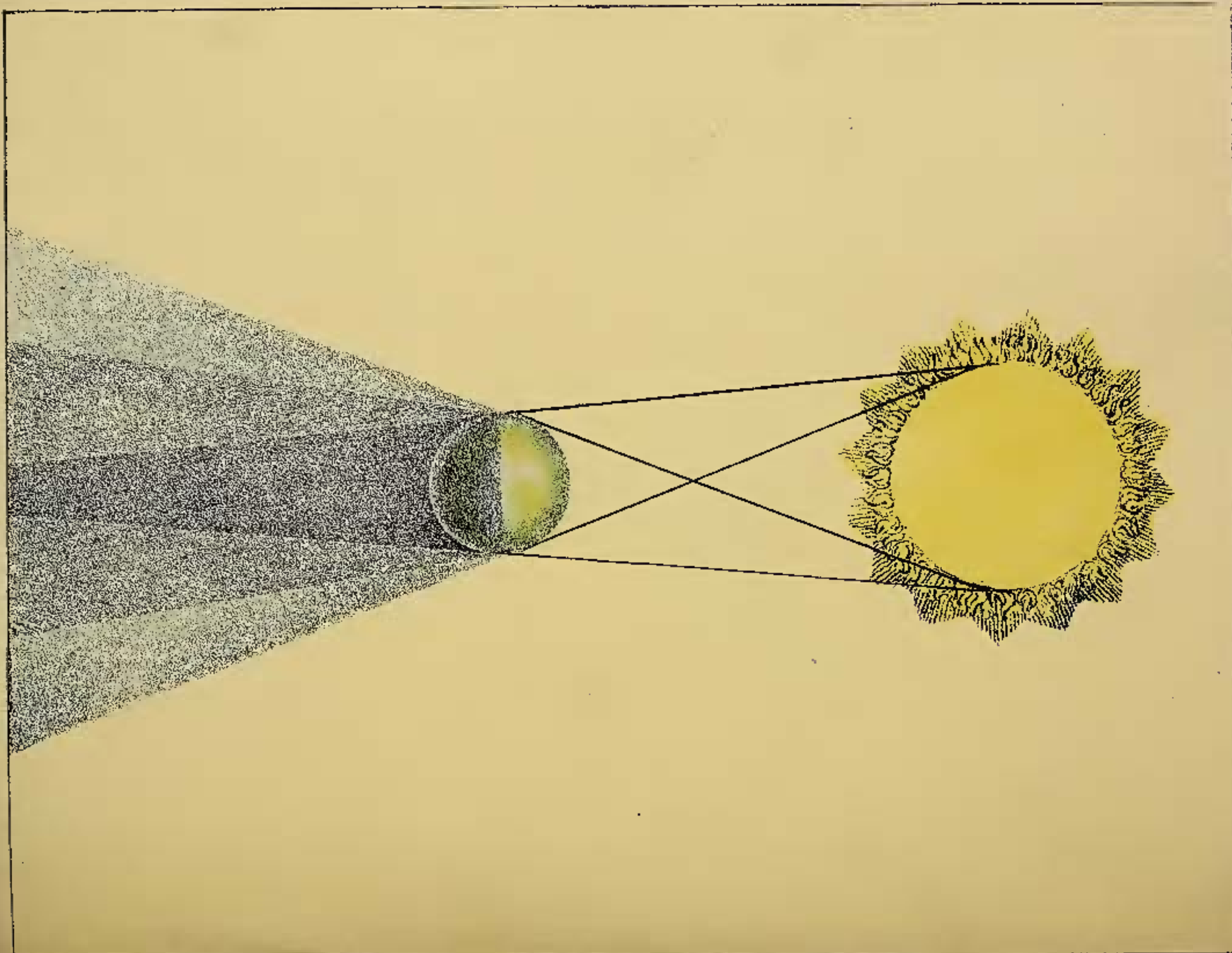
ORION.

CETUS

No. 54. THE SUN'S PLACE IN THE ECLIPTIC.

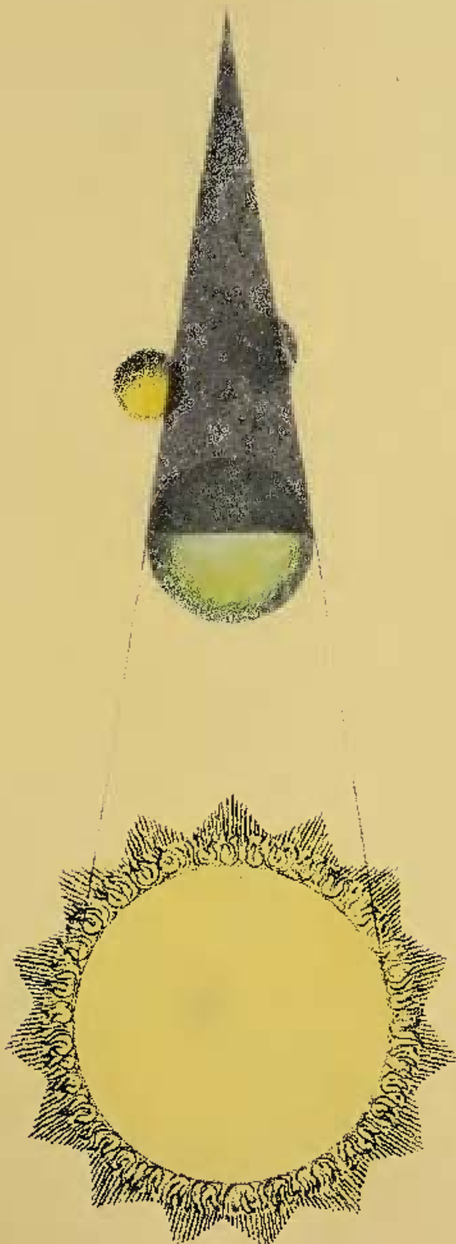


No. 6A. THE APPARENT RETROGRADE MOTION OF THE PLANETS.



No. 56 THE EARTH'S SHADOWS.

No. 57.



ECLIPSE OF THE MOON.

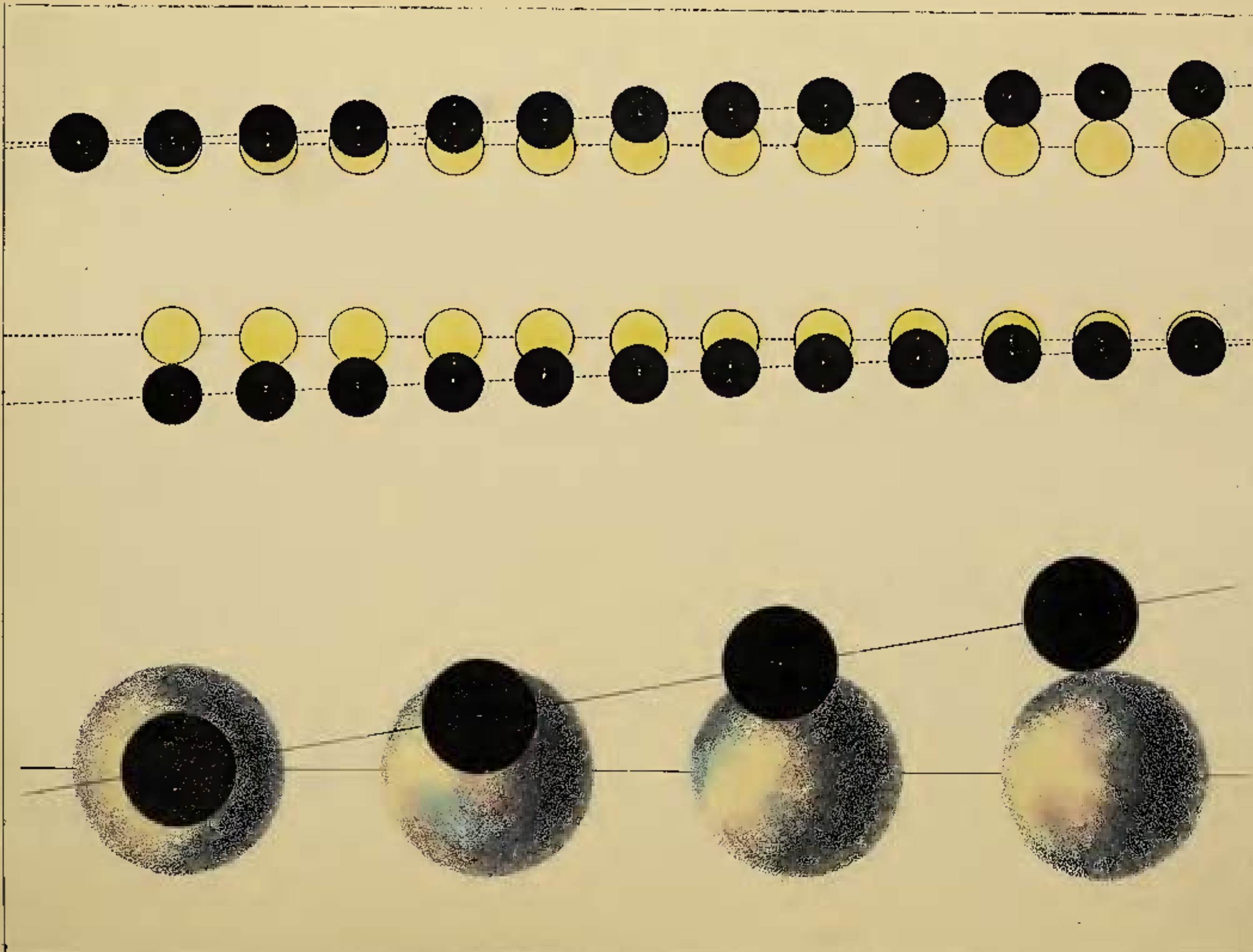
No. 58

ECLIPSE OF THE MOON.

Nº 59.

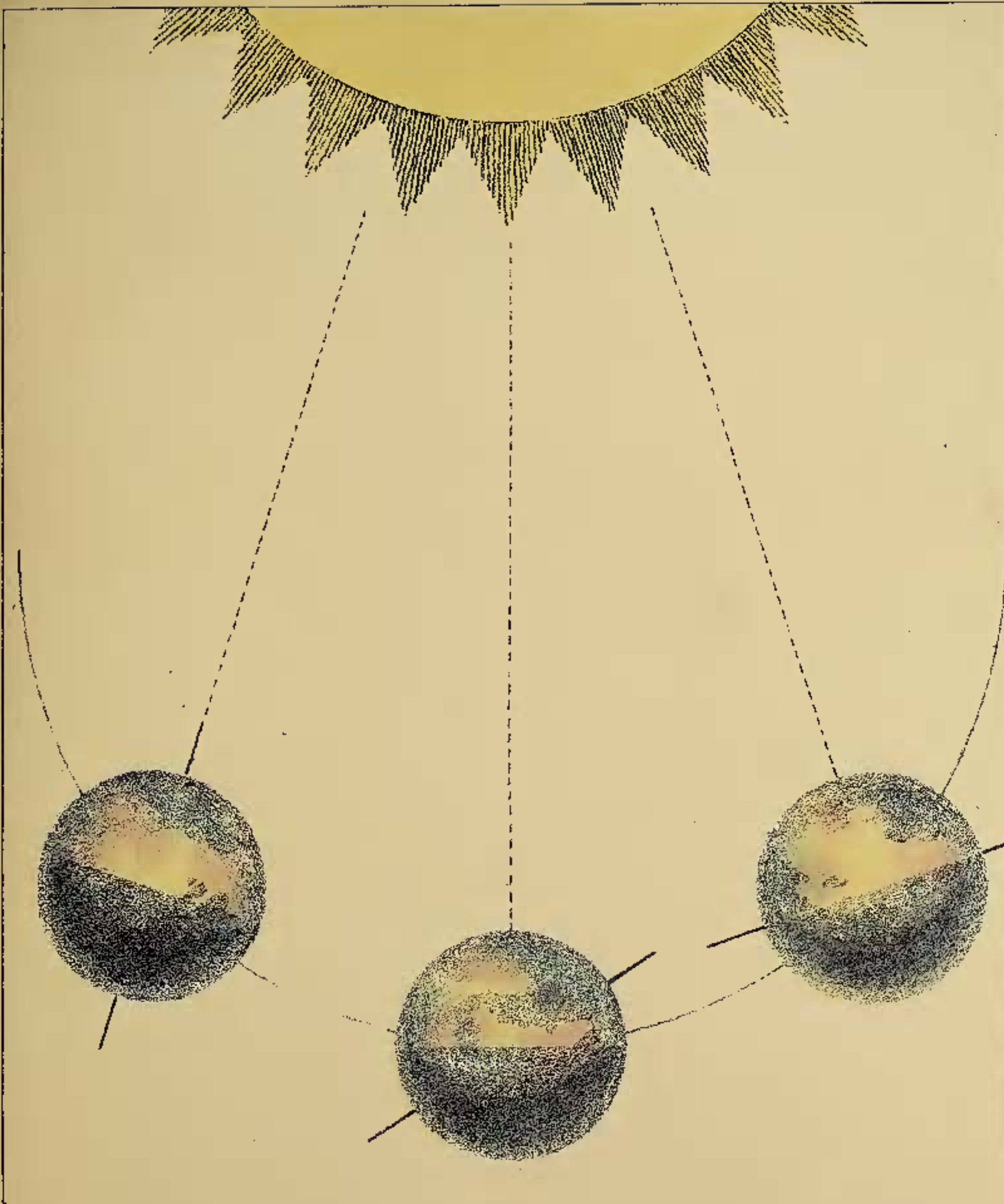
ECLIPSE OF THE SUN

N°60 ECLIPSE OF THE SUN.



No. 61. THE PROGRESS OF AN ECLIPSE.

No 62. ANNULAR ECLIPSE OF THE SUN.

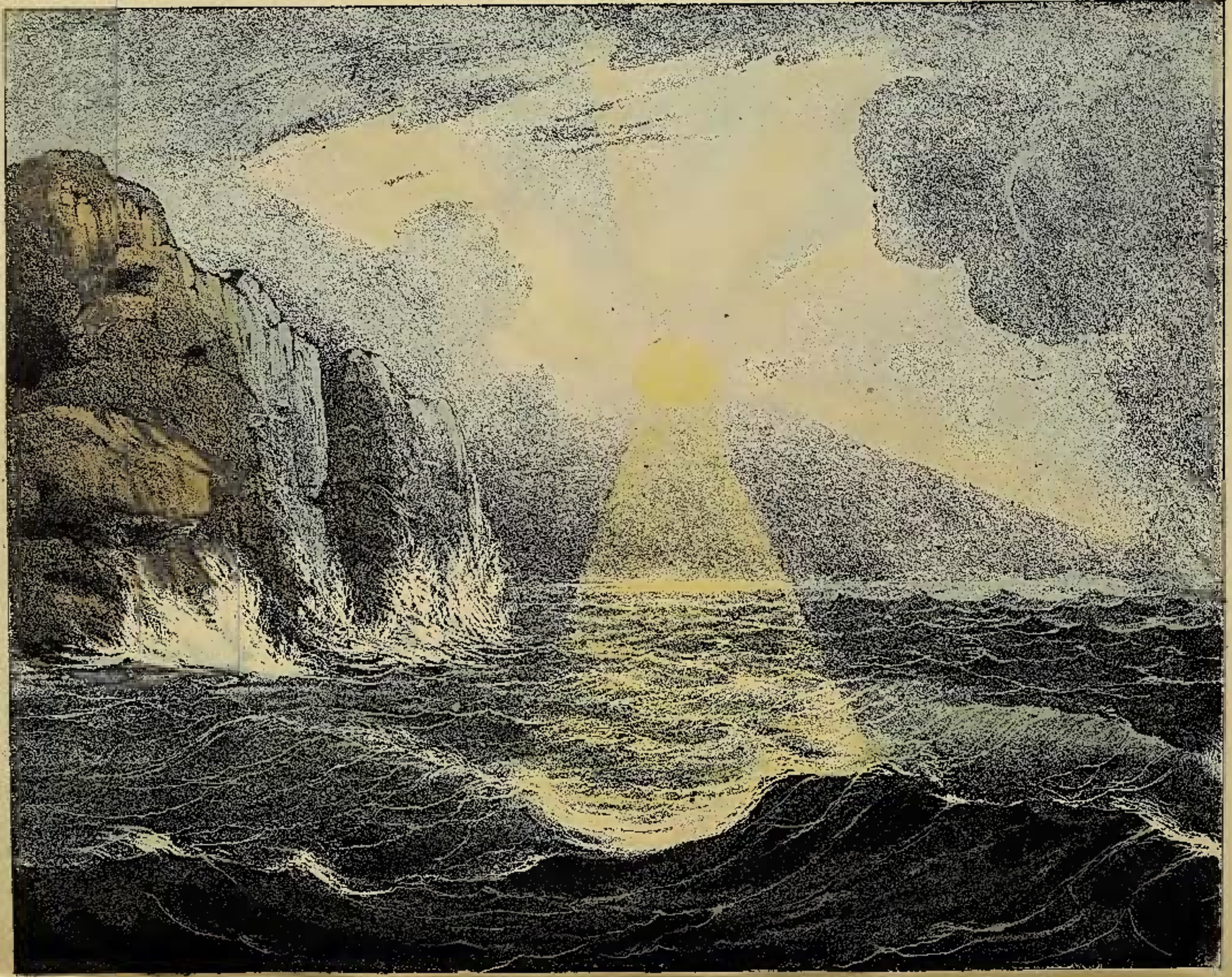


No. 63.

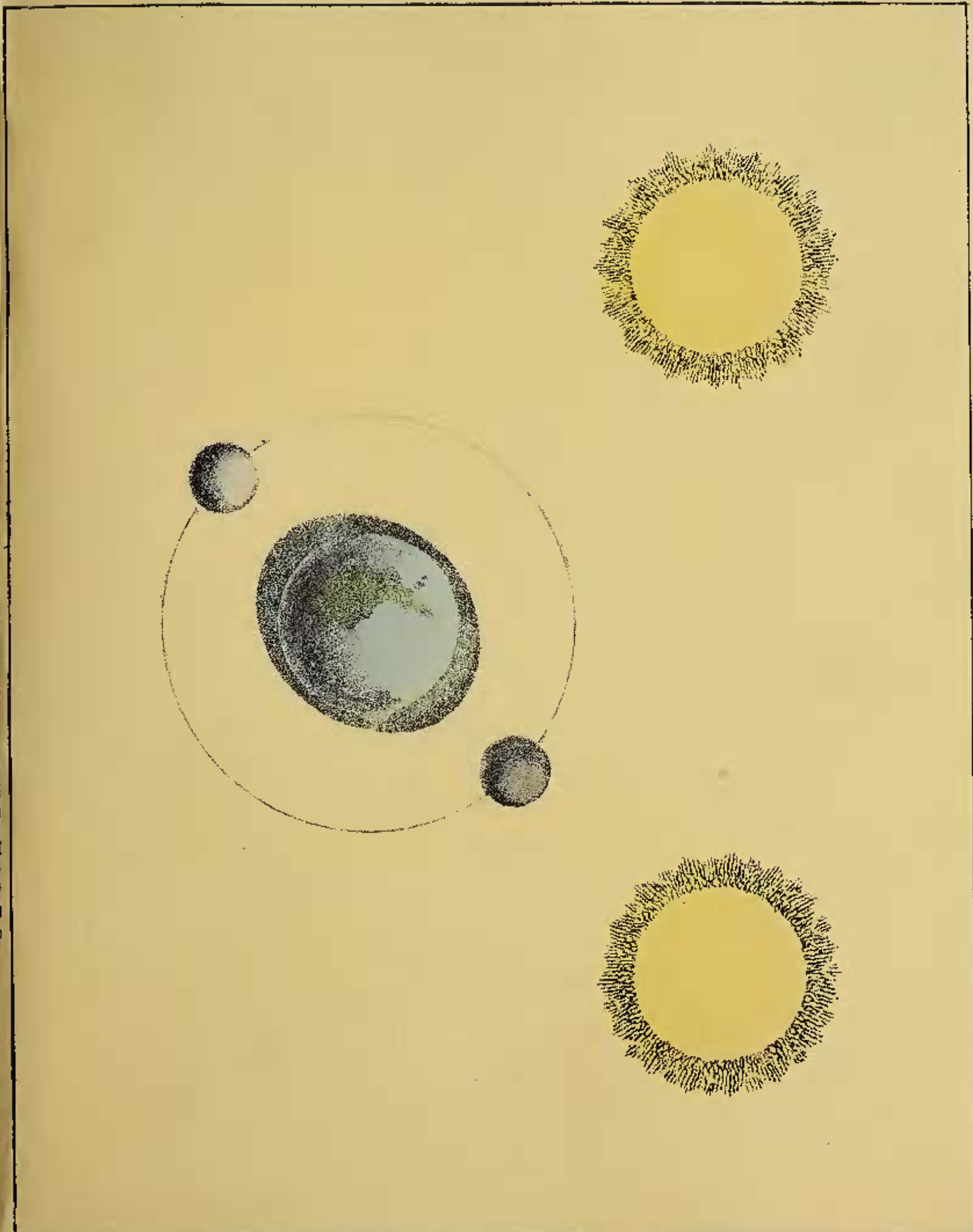
THE PHENOMENA OF THE SEASONS. No. I

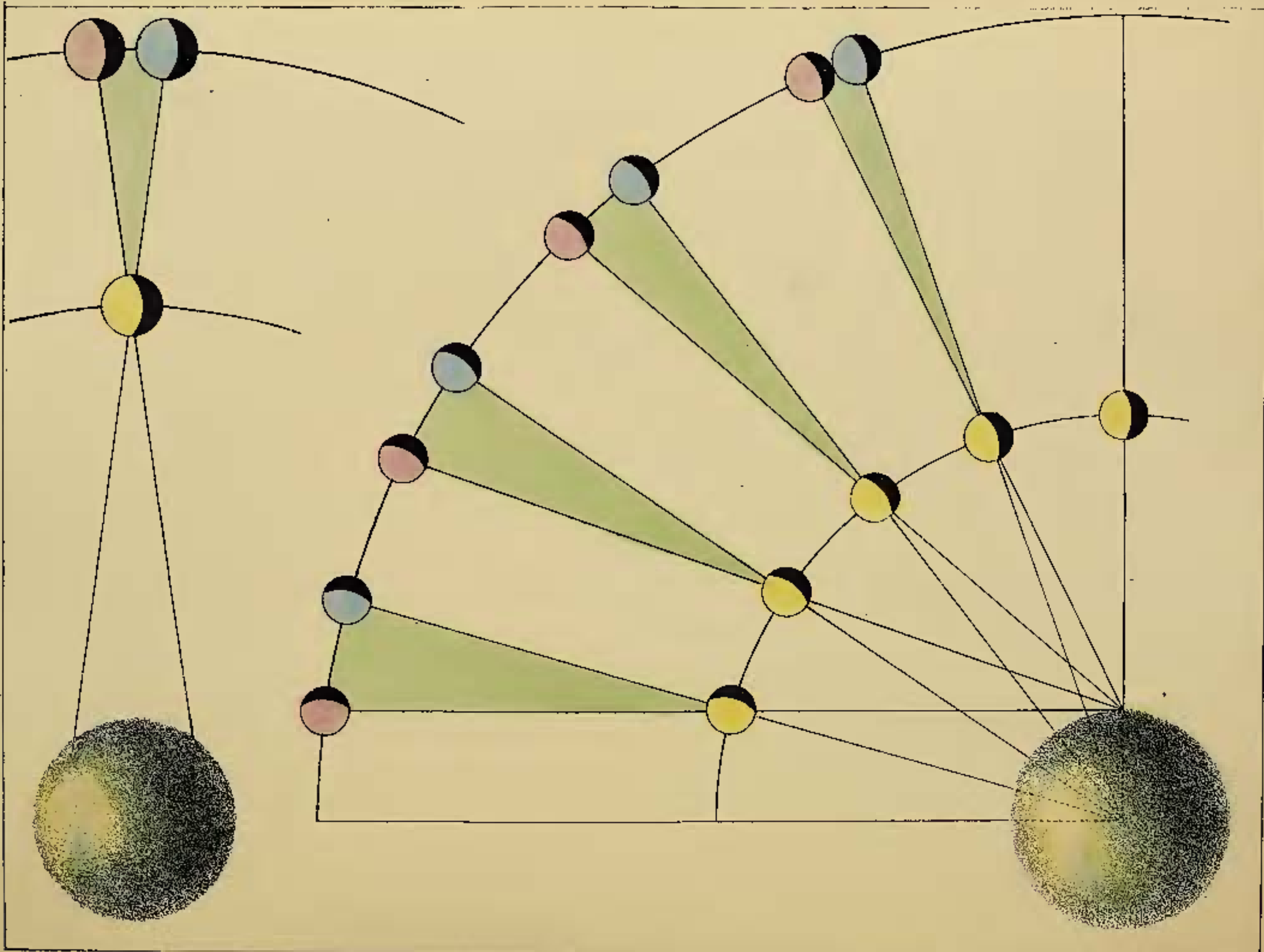
N° 64

THE PHENOMENA OF THE SEASONS. N° 2

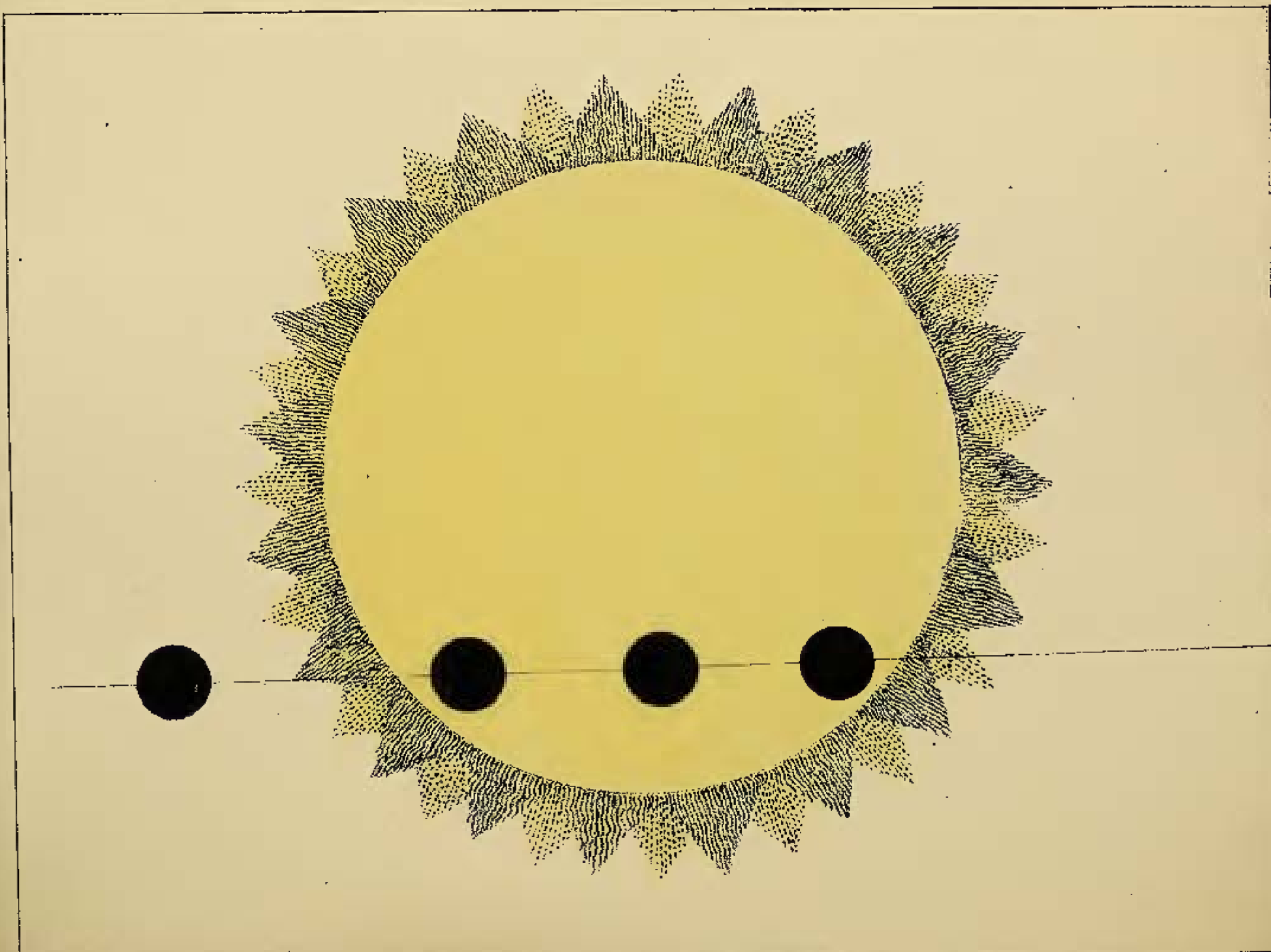


THE SUN AT MIDNIGHT AT THE NORTH CAPE.



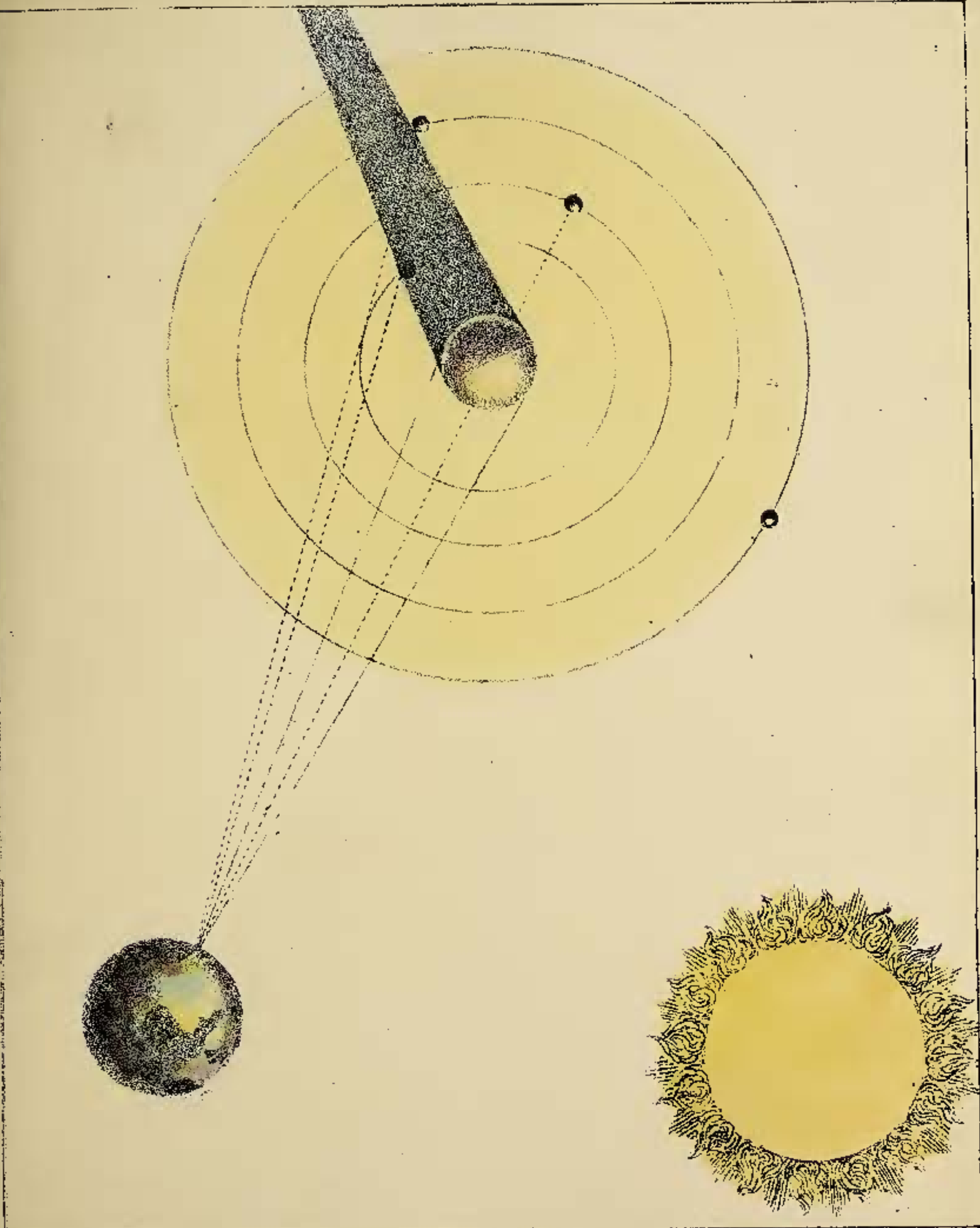


No. 67. THE PARALLAX OF THE PLANETS.

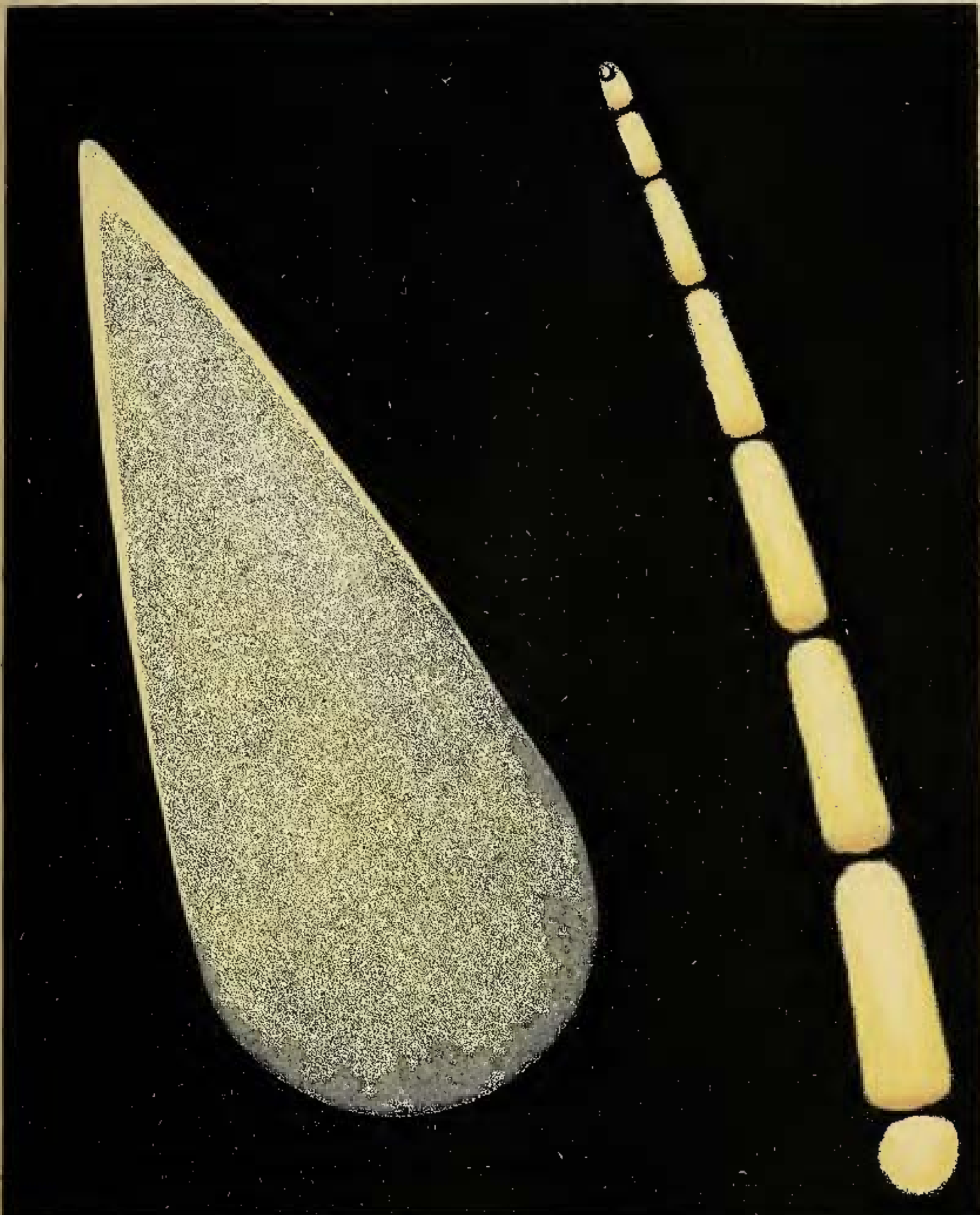


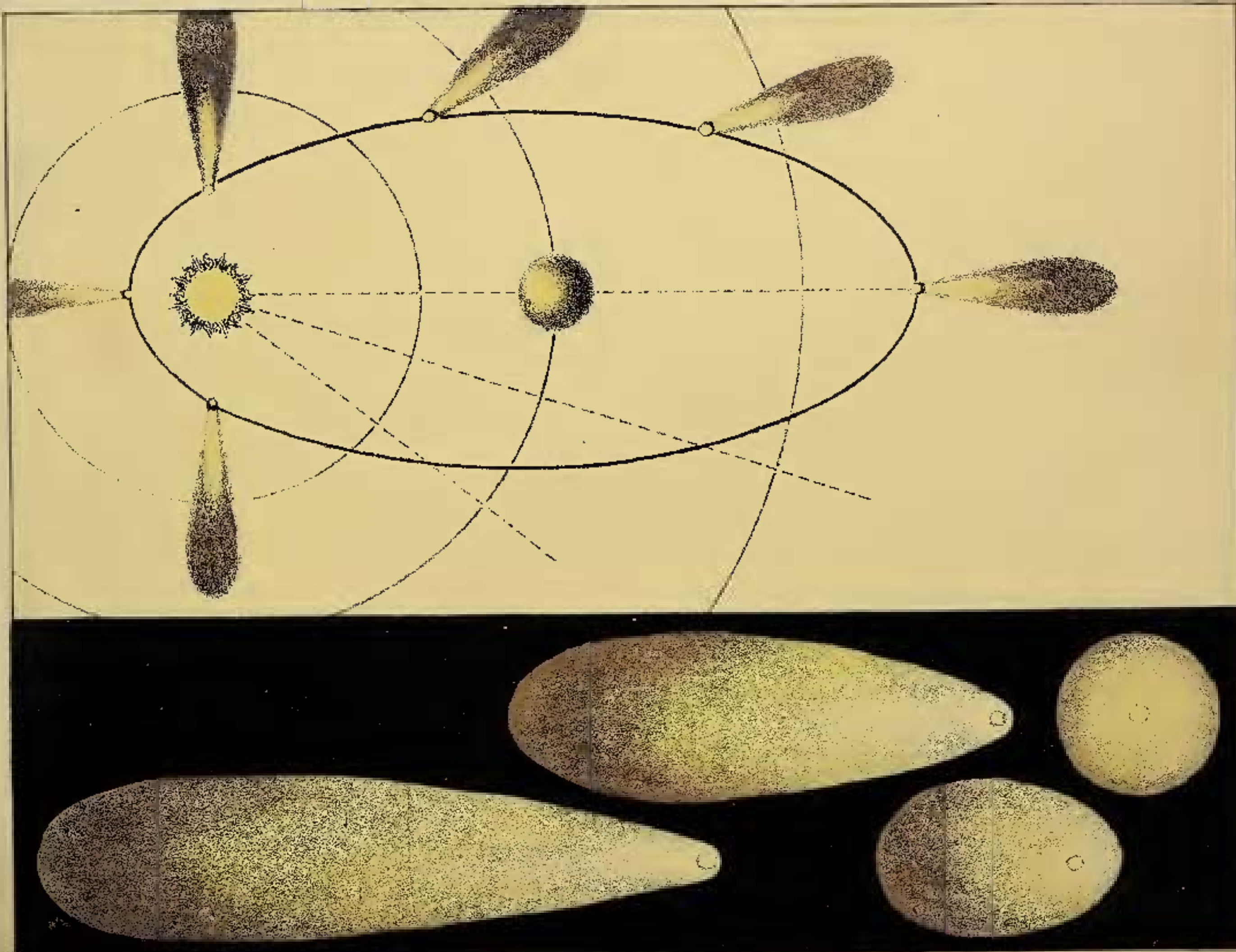
No. 68. TRANSIT OF VENUS OVER THE SUNS DISC.

Nº 60

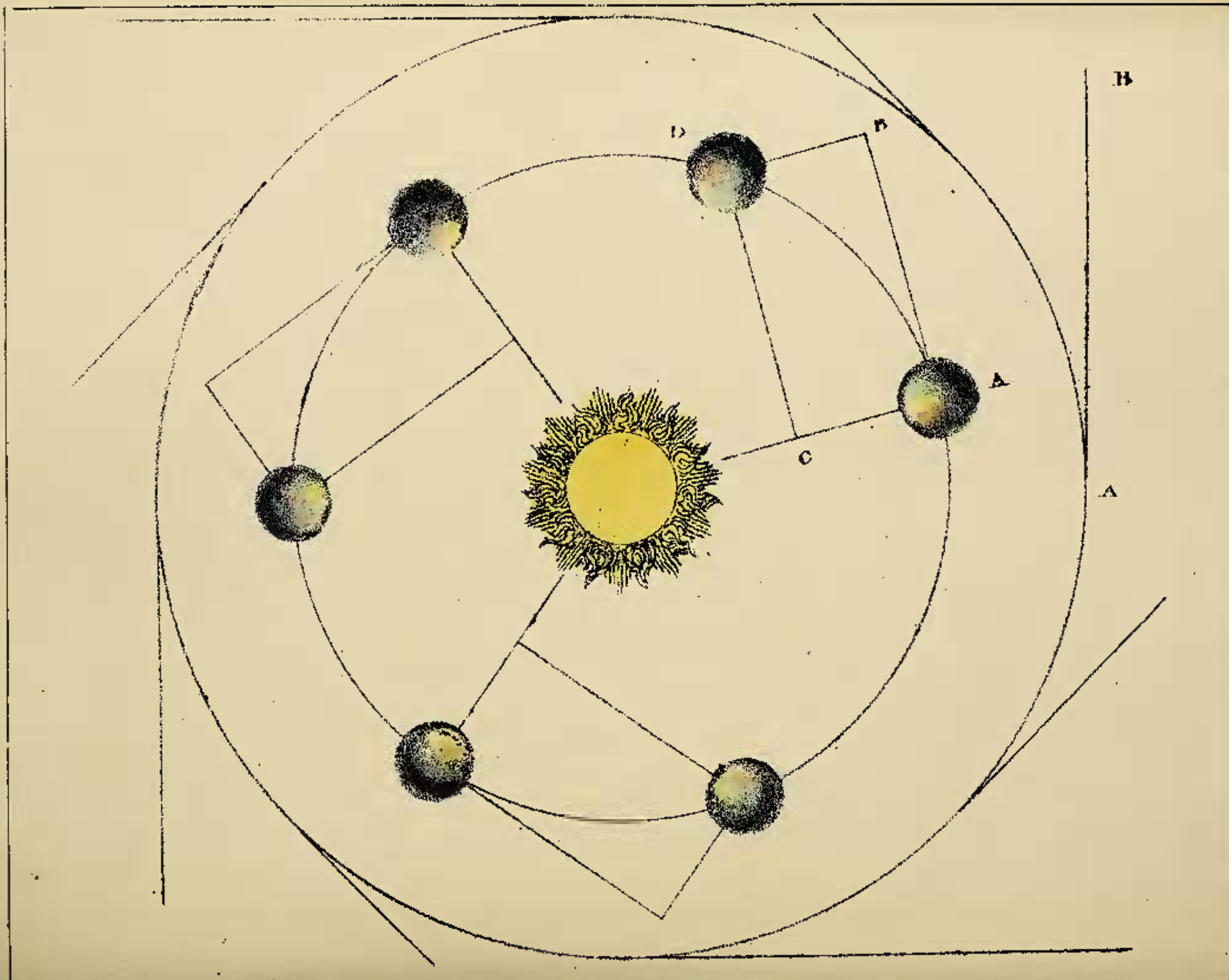


ECLIPSE OF JUPITER'S SATELLITES.

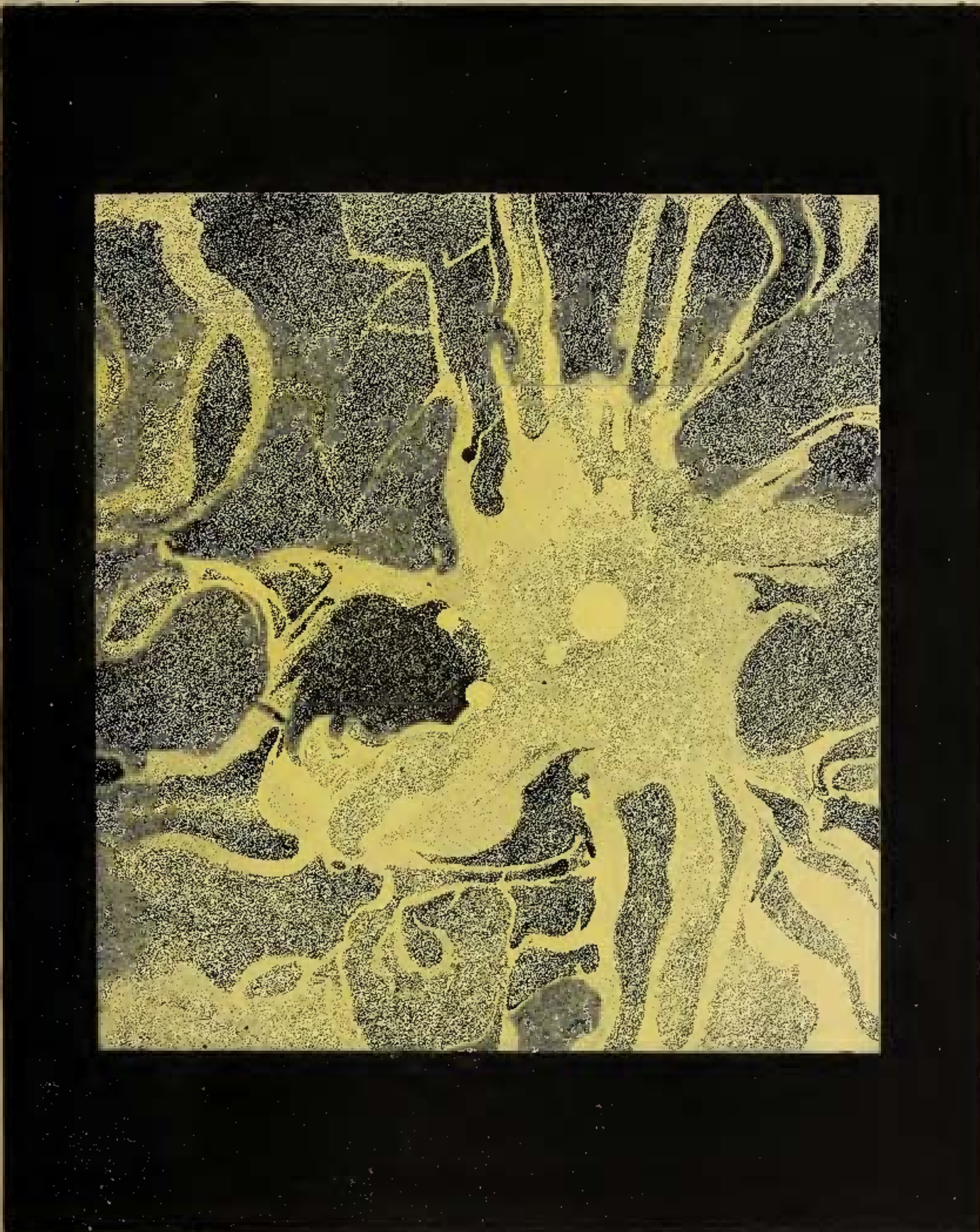




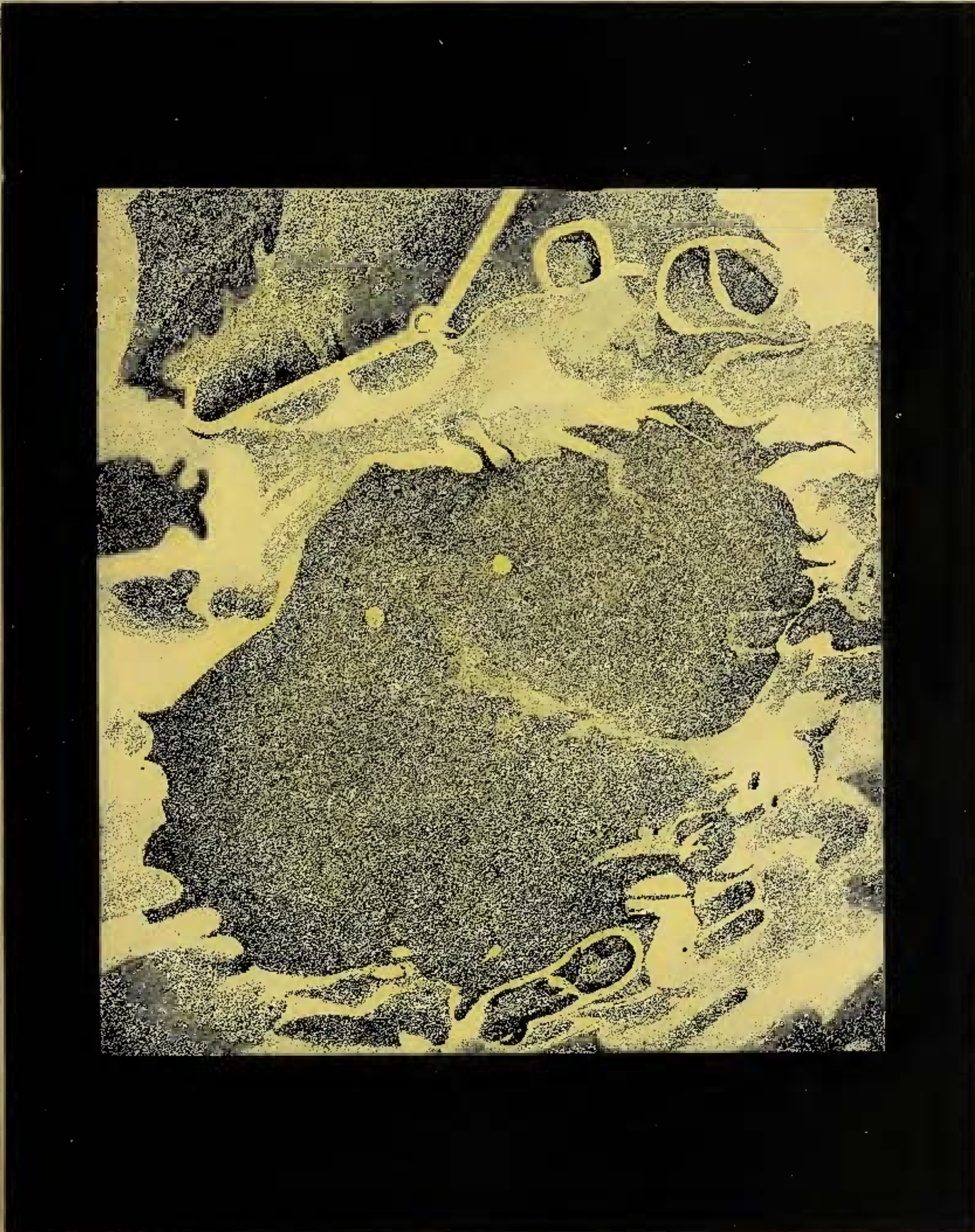
No 71. COMETARY MOTION.

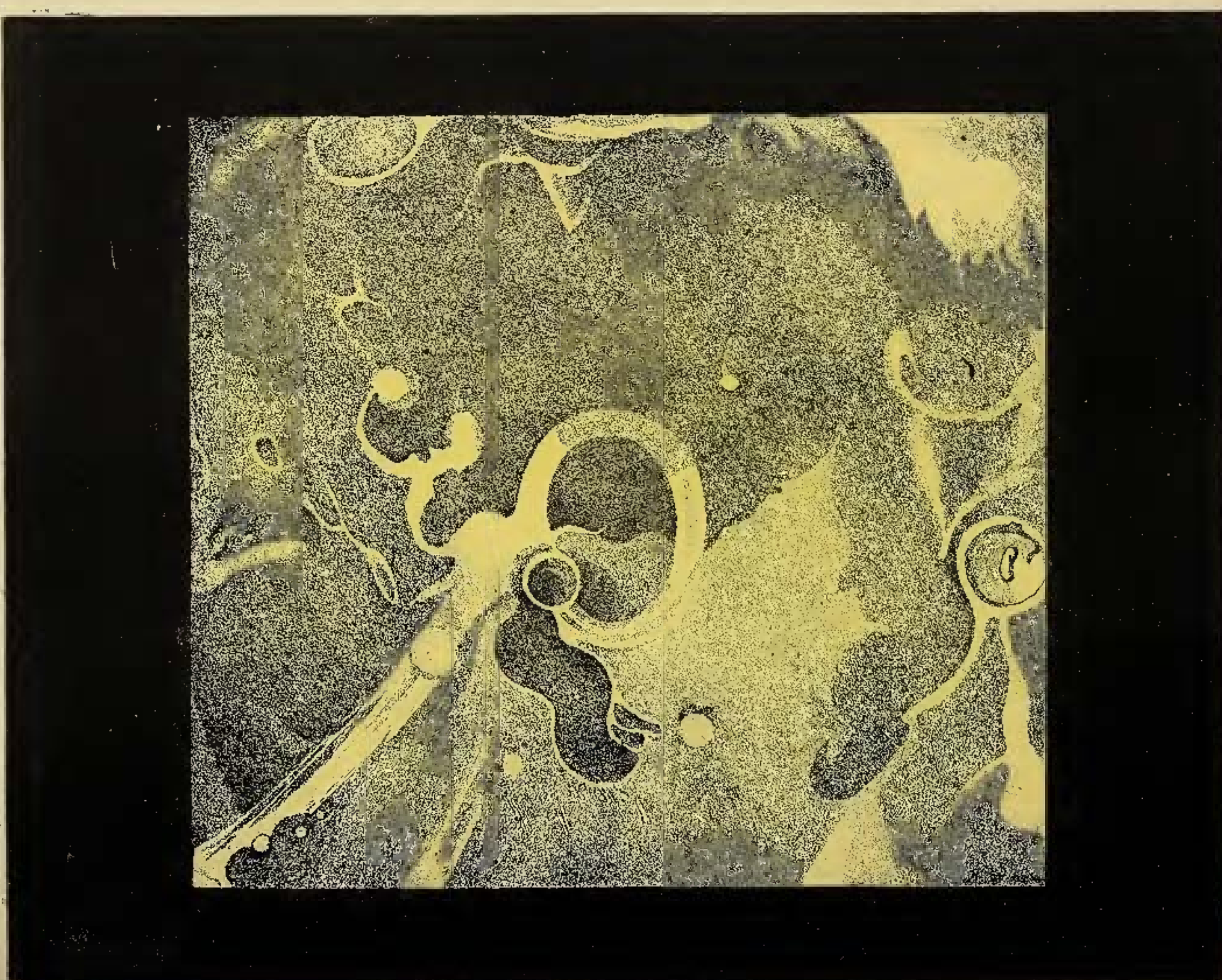


No. 12. THE LAWS OF PLANETARY MOTION



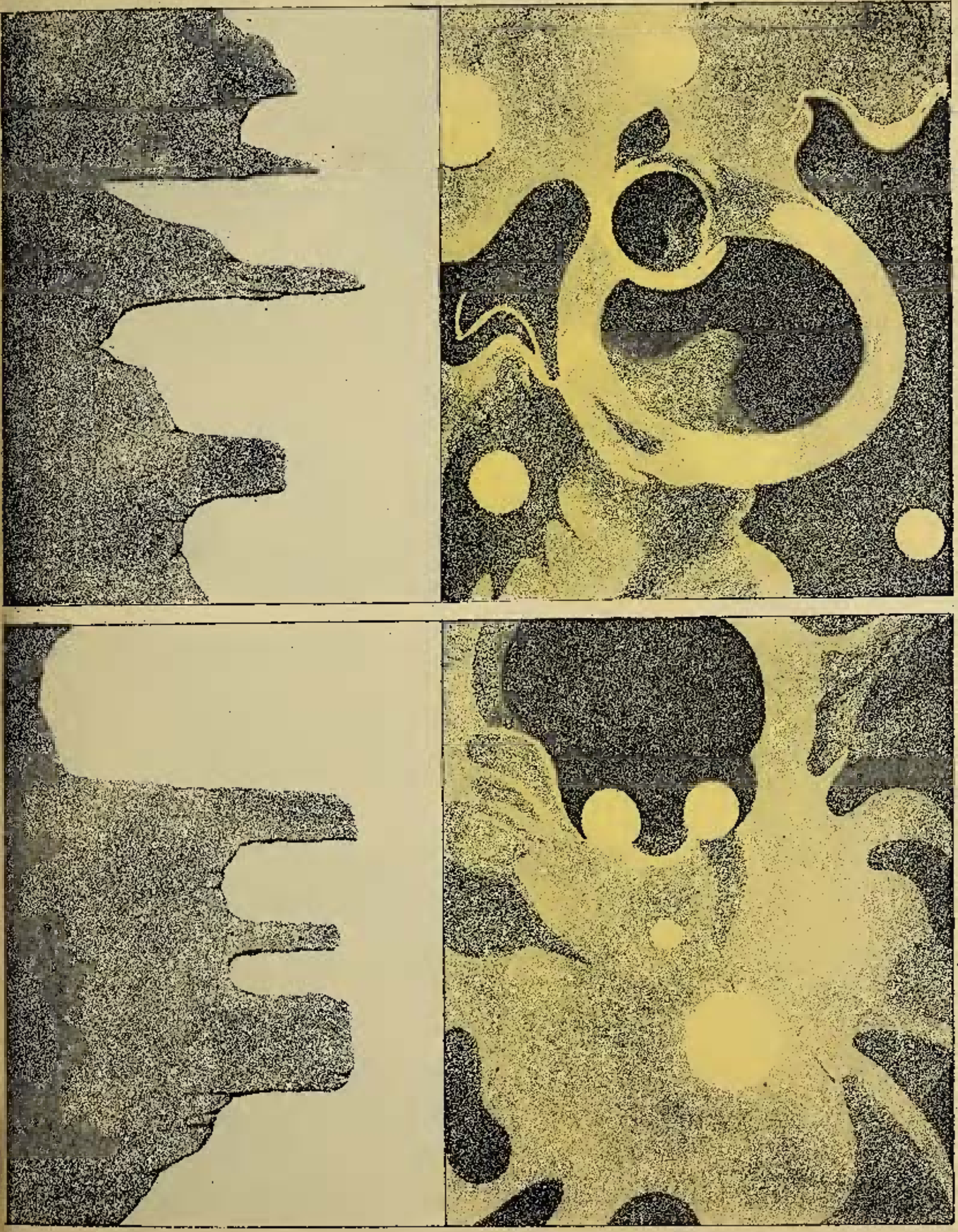
THE MOON'S SURFACE — KEPLER

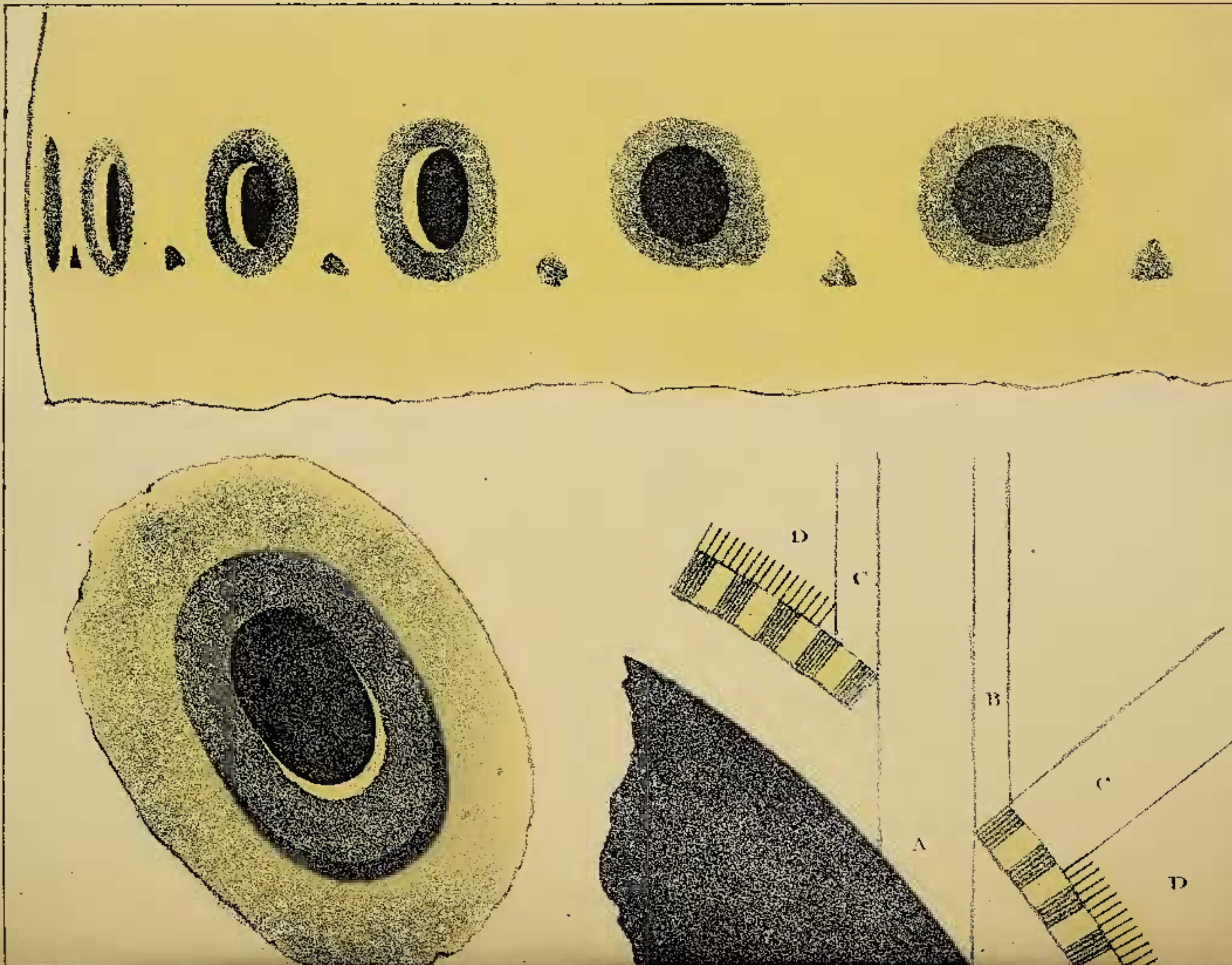




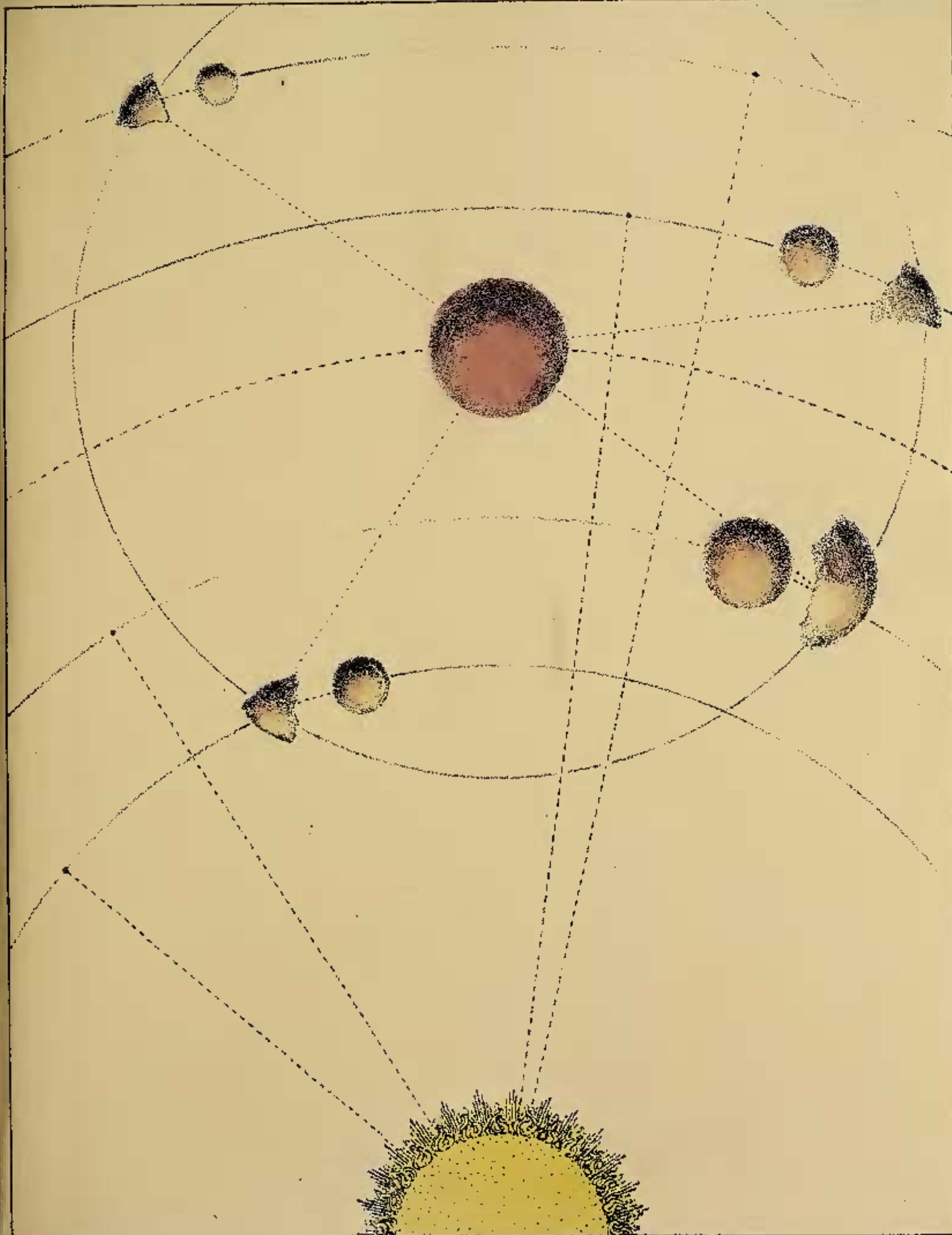
Nº 75. THE MOON'S SURFACE _ FRACASTORIUS.

THE MOON'S SURFACE TYCHO





No 78. CONSTITUTION OF THE SUN.



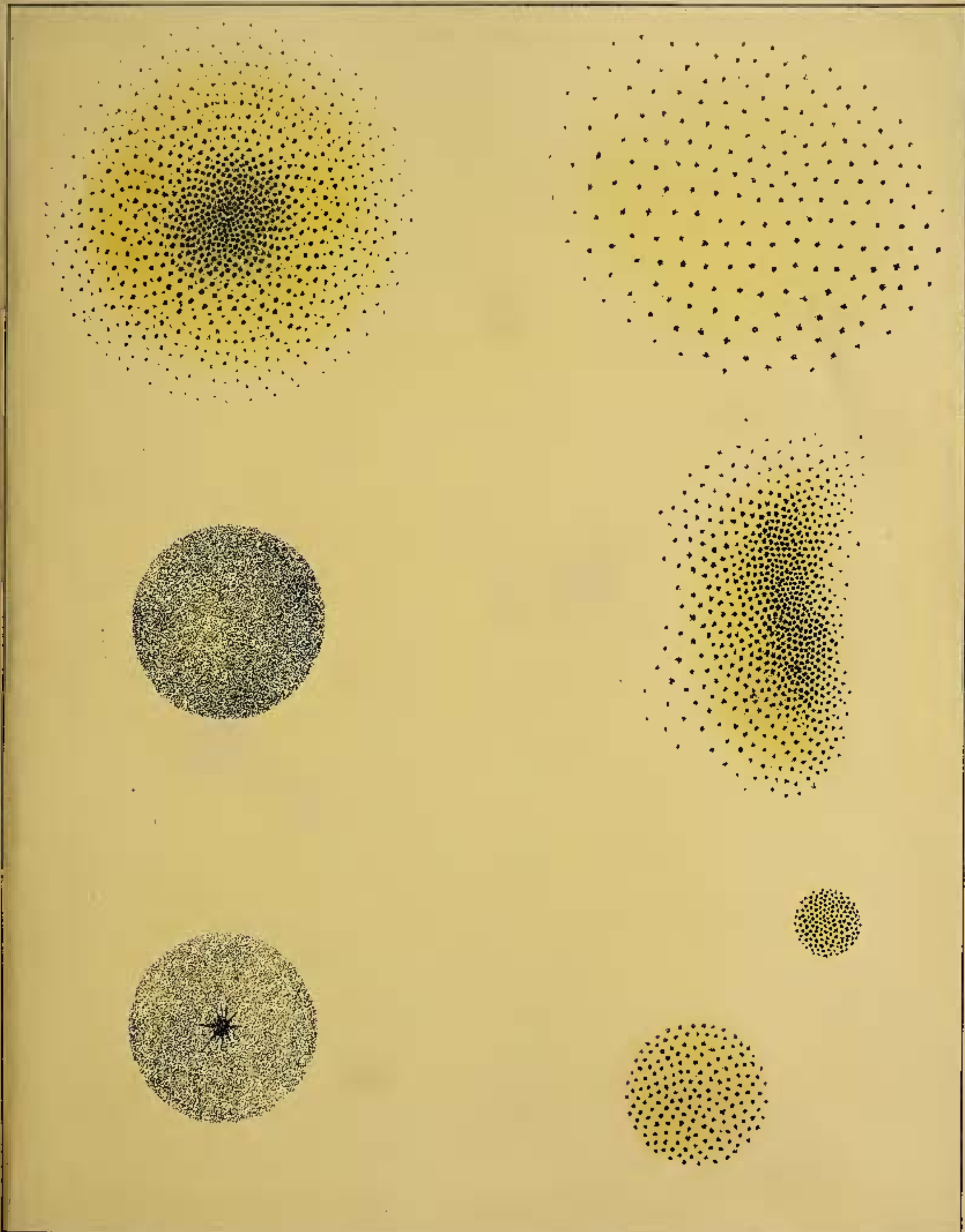
ORIGIN OF THE ASTEROIDS

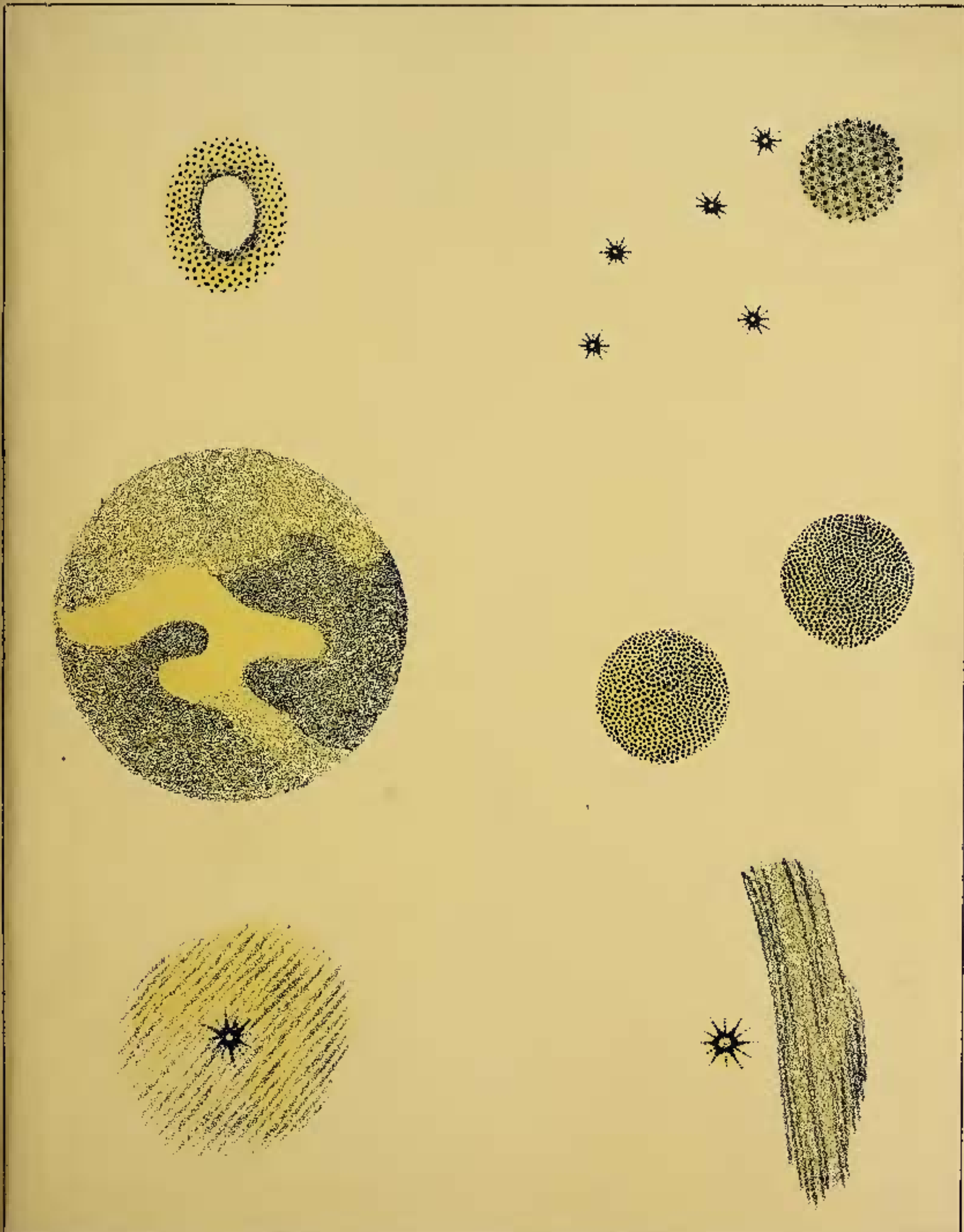
N° 20

THE MILKY WAY

N°31.

CLUSTERS OF STARS

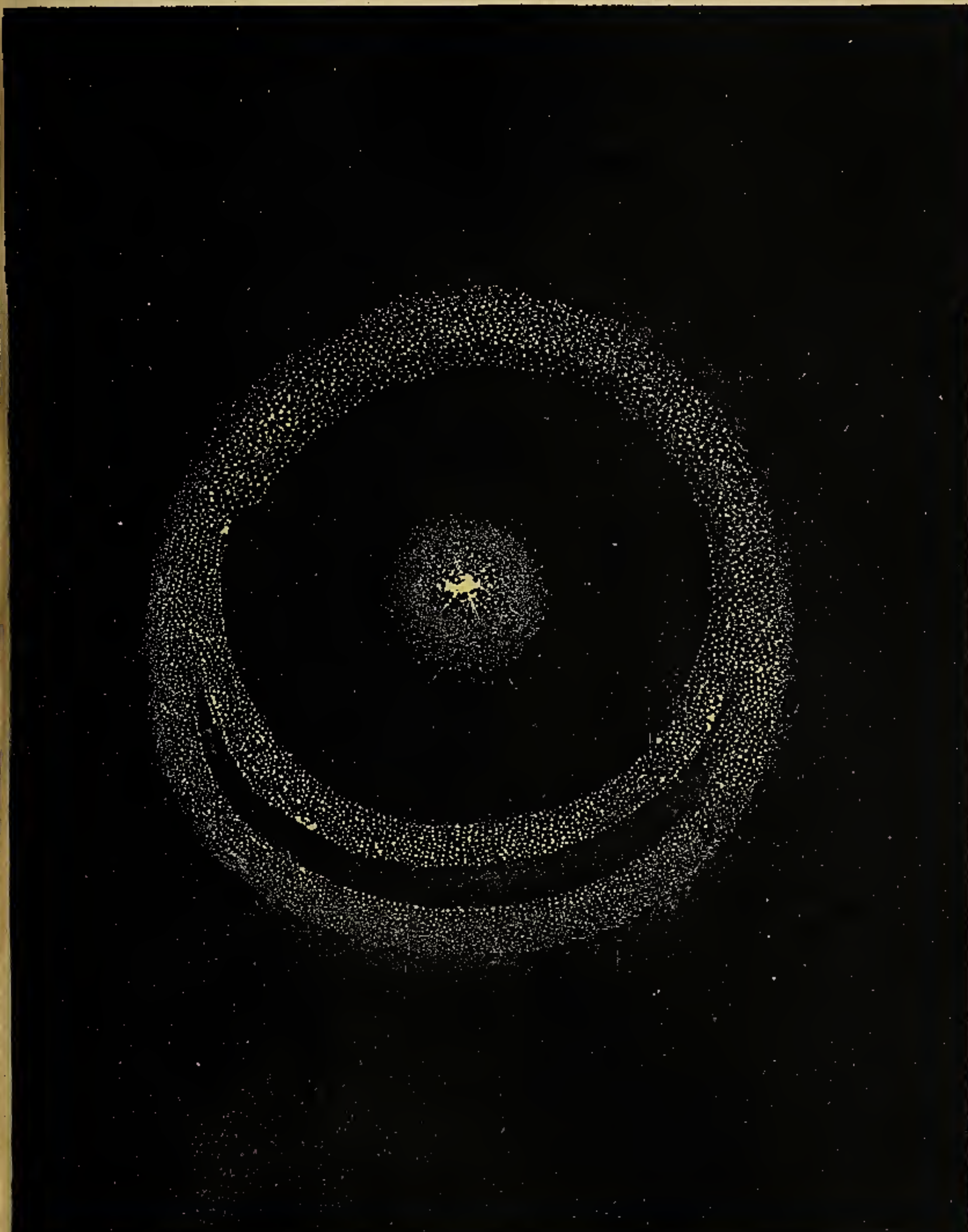




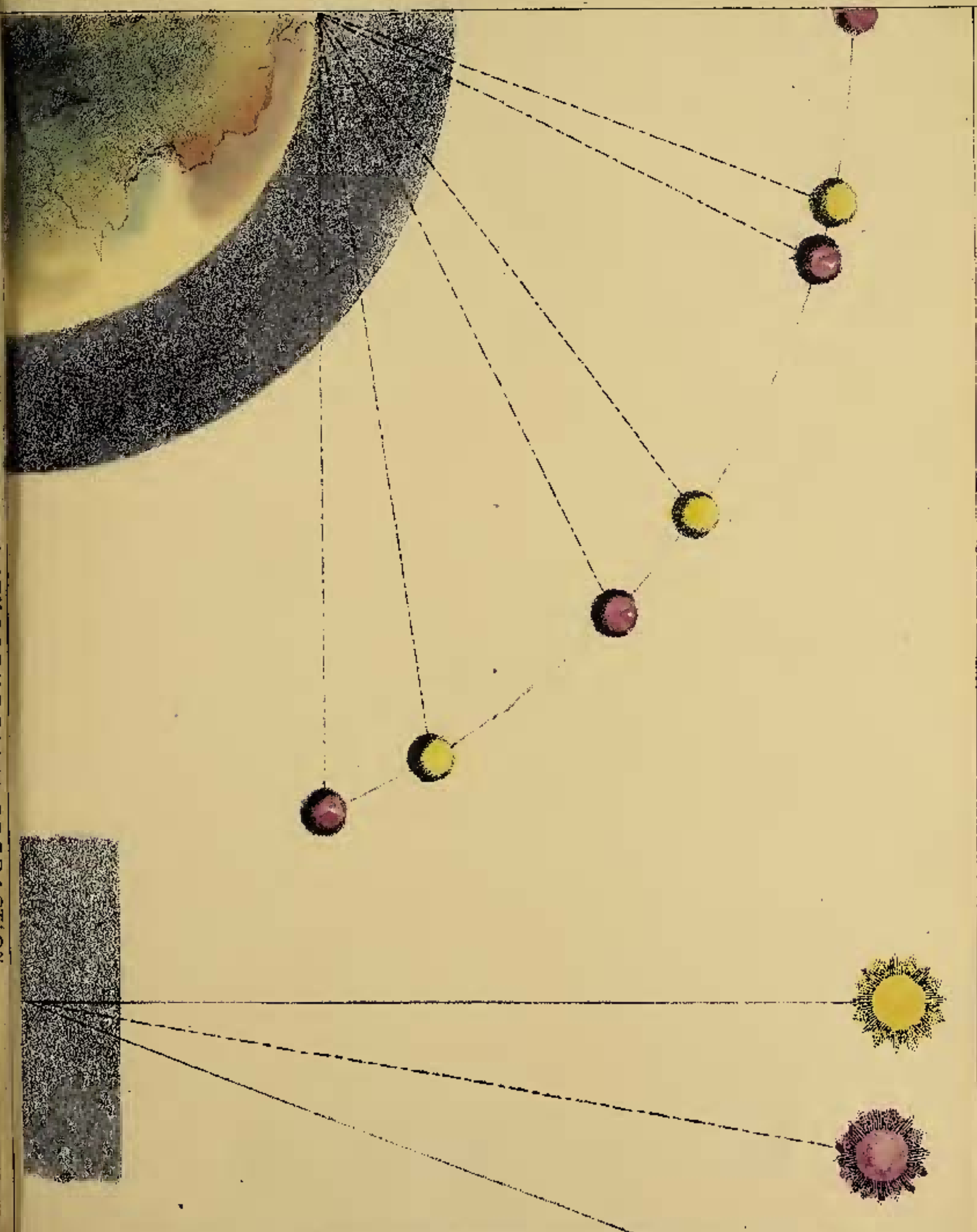
No 32. NEBULOUS STARS AND NEBULAE

THE NEBULA OF ANDROMEDA

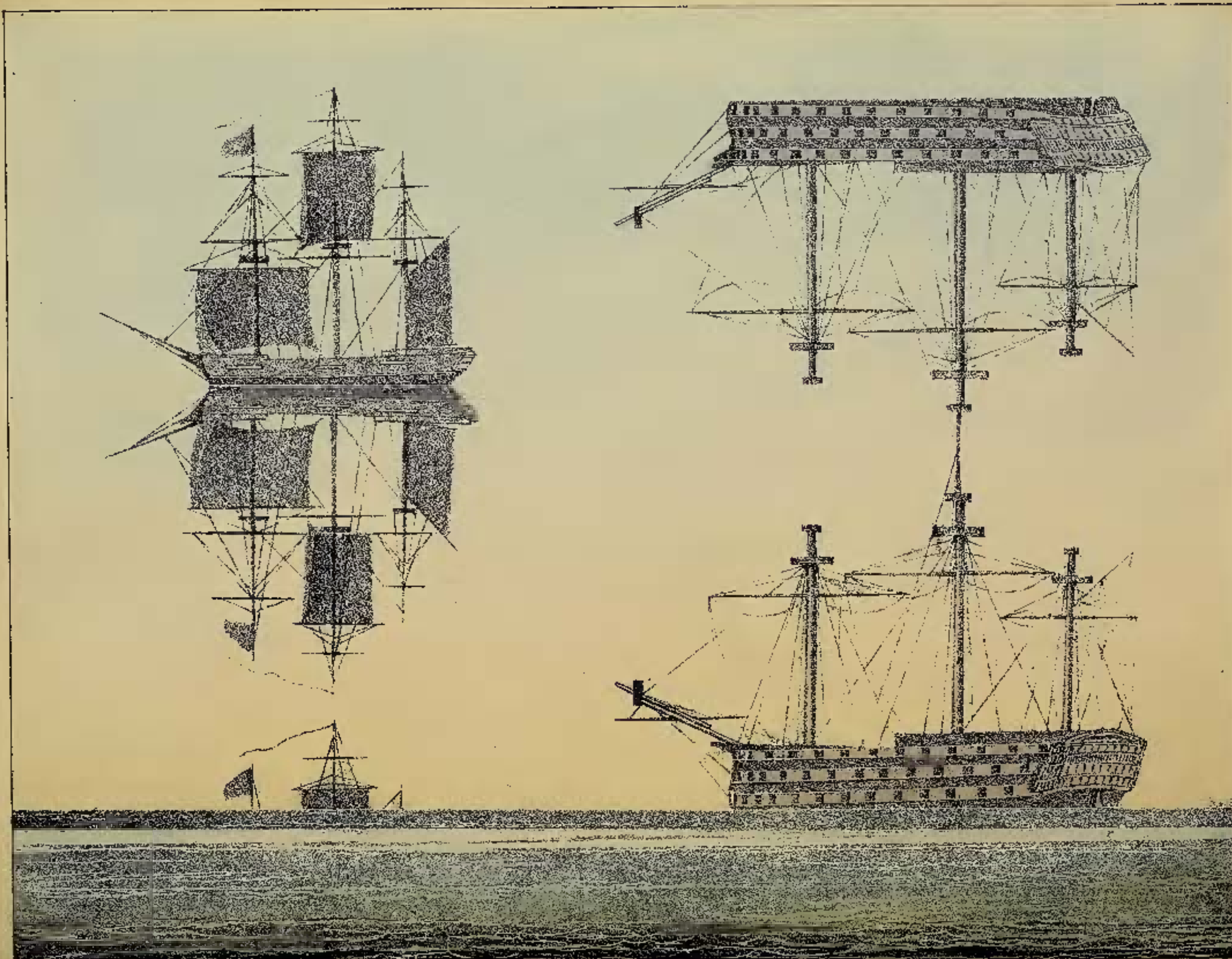
THE NEBULA OF ORION



CENTAUR, LUPUS, CRUX, MUSCA BOREALIS.



ATMOSPHERICAL REFRACTION



Nº 93. ATMOSPHERIC REFRACTION.

No. 94. AURORA BOREALIS.

N°95.

PARHELIA — N°1.

No. 96.

PARHELIA — No. 2.

Nº 97. THE ZODIACAL LIGHT.

No. 98. CLOUDS — CIRRUS

No 99. CIRRO — CUMULUS.

No. 104. CLOUDS - CIRRO - STRATUS.

CLOUDS STRATUS

NIMBUS — OR RAIN CLOUD.

No 104. THE RAIN[illegible]

THE

BEAUTY OF THE HEAVENS:

A PICTORIAL DISPLAY

OF

THE ASTRONOMICAL PHENOMENA

OF

THE UNIVERSE.

ONE HUNDRED AND FOUR COLOURED SCENES ILLUSTRATING

A Familiar Lecture on Astronomy.

BY CHARLES F. BLUNT.

LECTURER ON ASTRONOMY AND NATURAL PHILOSOPHY; AUTHOR OF "THE WONDERS OF THE TELESCOPE, AN ELEMENTARY LECTURE ON ASTRONOMY," ETC. ETC.

NEW EDITION.

LONDON:

TILT AND BOGUE, FLEET STREET.

MDCCCXLII.

INTRODUCTION.

The want of a series of Plates for the illustration of the Science of Astronomy, of accurate, yet popular character, calculated for effective display, and still within a moderate compass, has led to the production of the present Work. The design comprehends 104 coloured Scenes, representing the Astronomical Phenomena of the Universe. These have been carefully executed from original drawings, paintings, and observatory studies; aided, occasionally, by appropriate pictorial embellishment, but with strict adherence to fidelity of detail.

Although these Scenes may be considered as forming a tasteful Appendix to every popular treatise on Astronomy, they are accompanied by the following familiar Lecture on the Science, explanatory of the phenomena represented, so as to render recourse to other elementary works unnecessary. The design is thus made unique; and great pains have been taken to insure accuracy alike in its pictorial and scientific departments.

The Illustrations form the miniature scenery of a public exhibition, such as is occasionally witnessed in lecture-rooms; the text presenting the substance, the order, and the actual delivery of what becomes, in the present instance, a Family Astronomical Lecture. The prominent features of the present Work are, the novelty and simplicity of the plan, and the elegance of its execution. With its aid a family need not henceforth quit their own parlour, or drawing-room fireside, to enjoy the sublime "beauty of the heavens;" but, within their domestic circle, may, without any previous acquirements in Astronomy, become their own instructors in a knowledge of its great and leading truths and phenomena. The Lecture may be read aloud by a parent, teacher, or any member of a party, the Scenes being exhibited, at the same time, in the numerical succession corresponding to their order of description. It would be impossible to devise a more rational, or, to a well-regulated mind, a more cheerful mode of passing an evening; or of inculcating the Divine lesson, of looking "through Nature up to Nature's God."

Each portion of the design may be said to aid the other: the scenes, by their attractive beauty, at once appeal to the eye, and can scarcely fail to impress the mind of the spectator; whilst the accompanying details serve to reciprocate these pleasing effects, and infix them on the memory.

The Lecture is, for convenience, divided into two equal portions, so as to occupy two evenings, if desired. In its preparation, simplicity and plainness of language have been preferred to any laboured display of technical knowledge. The Author has avoided the use of such scientific terms as can be legitimately dispensed with; and has fully explained those which are requisite for perspicuity: and, extensive utility being the object in view, the omission of such matter as cannot readily be divested of difficult terms, has been preferred to the hazard of not being fully understood.

In conclusion, if the Author's views be correct, and his mode of embodying them obtain the countenance of those whose mastery in the Science renders their approval the only true fame, his utmost hopes will be realized, and much intellectual gratification insured to the domestic circle.

LIST OF THE SCENES, AND REFERENCES TO THE DESCRIPTIONS.

PART I.

SCENE. PAGE.

No. I.—The Fixed Stars .... described at 3
II.—The Earth: its Form, and Position in Space 14
III.—The Earth: its true Figure and Dimensions 15
IV.—The Planetary System 19
V.—Mercury, Venus, the Earth, and Mars 21
VI.—The Earth, Inferior Planets, and the Asteroids Vesta, Juno, Ceres, and Pallas 21
VII.—The Sun's Disc 28
The Planet Mercury 30
VIII.—The Planet Venus 31
IX.—The Planet Mars 33
The Planet Vesta 34
The Planet Juno 34
The Planet Ceres 34
The Planet Pallas 35
X.—The Planet Jupiter 35
XI.—The Planet Saturn 37
XII.—The Planet Herschel, or Uranus 39
XIII.—The Moon at the Full 41
XIV.—The Nomenclature of the Lunar Spots 45
XV.—The Moon's Phases 46
XVI.—The Crescent Moon. No. 1 48
XVII.—The Crescent Moon. No. 2 49
XVIII.—The Moon Gibbous 49
XIX.—The Waning Moon 50
XX.—The Phases of the Planet Saturn 50
XXI.—The Relative Sizes of the Planets 54

PART II.

Distances of the Planets 55
The Animated Orrery 56
XXII.—The Sun as seen from the different Planets 59
XXIII.—The Constellations of the Northern Hemisphere 60
XXIV.—The Constellation Ursa Major 64
XXV.—Draco.—Ursa Minor 65
Draco 65
XXVI.—Lynx 65
XXVII.—Auriga 65
XXVIII.—Perseus 66
XXIX.—Andromeda 66
XXX.—Cassiopeia 66
XXXI.—Pegasus 67
XXXII.—Cygnus—Lyra 67
XXXIII.—Cepheus 67
XXXIV.—Hercules 67
XXXV.—Bootes 67
XXXVI.—Ophiucus 68
XXXVII.—Aquila—Antinous 68
XXXVIII.—Aries 68
XXXIX.—Taurus 68
XL.—Gemini 69
XLI.—Cancer 69
XLII.—Leo 69
XLIII.—Virgo 69
XLIV.—Libra 70

SCENE. PAGE.
No. XLV.—Scorpio....described at 70
XLVI.—Sagittarius 70
XLVII.—Capricornus 70
XLVIII.—Aquarius 70
XLIX.—Pisces.... 70
L.—Monoceros and Canis Minor 71
LI.—Canis Major.... 71
LII.—Orion 71
LIII.—Cetus.... 71
To observe the Stars by Day or Night.... 75
LIV.—The Sun's Place in the Ecliptic.... 77
LV.—The Apparent Retrograde Motion of the Planets.... 77
LVI.—The Earth's Shadows 78
LVII.—Eclipse of the Moon.... 78
LVIII.—Eclipse of the Moon.... 79
LIX.—Eclipse of the Sun 80
LX.—Eclipse of the Sun 80
LXI.—The Progress of an Eclipse 80
LXII.—An Annular Eclipse of the Sun.... 81
LXIII.—The Phenomena of the Seasons. No. 1.... 81
LXIV.—The Phenomena of the Seasons. No. 2.... 82
LXV.—The Sun at Midnight, at the North Cape.... 83
LXVI.—The Phenomena of the Tides 83
LXVII.—The Parallax of the Planets 84
LXVIII.—The Transit of Venus over the Sun's Disc 85
LXIX.—The Eclipse of Jupiter's Satellites.... 85
LXX.—Comets.... 86
LXXI.—Cometary Motion.... 87
LXXII.—The Laws of Planetary Motion.... 87
LXXIII.—The Moon's Surface: Kepler.... 88
LXXIV.—The Moon's Surface: Cleomedes 89
LXXV.—The Moon's Surface: Fracastorius 89
LXXVI.—The Moon's Surface: Tycho.... 89
LXXVII.—The Constitution of the Moon 90
LXXVIII.—The Constitution of the Sun 90
LXXIX.—The Origin of the Asteroids 91
LXXX.—The Milky Way.... 91
LXXXI.—Clusters of Stars.... 92
LXXXII.—Nebulous Stars and Nebulæ.... 92
LXXXIII.—The Nebula of the Constellation Hercules 93
LXXXIV.—The Nebula of the Constellation Andromeda.... 93
LXXXV.—The Nebula of the Constellation Orion 93
LXXXVI.—The Great Nebula of the Solar System.... 93
LXXXVII.—The Constellations of the Southern Hemisphere.... 94
LXXXVIII.—Centaur, Lupus, Crux, Musca Borealis 94
LXXXIX.—The Constellation Argo Navis 94
XC.—The Constellations Indus, Pavo, Grus, Toucan 95
XCI.—Explanation of Atmospherical Refraction 95
XCII.—The Horizontal Moon 96
XCIII.—Atmospheric Refraction 96
XCIV.—The Aurora Borealis 97
XCV.—Parhelia. No. 1.... 97
XCVI.—Parhelia and Halos. No. 2. 98
XCVII.—The Zodiacal Light.... 98
XCVIII.—Clouds—Cirrus 99
XCIX.—Clouds—Cirro-Cumulus 99
C.—Clouds—Cirro-Stratus.... 99
CI.—Clouds—Stratus 99
CII.—Clouds—Cumulus 100
CIII.—Clouds—Nimbus, or Rain-Cloud....100
CIV.—The Rainbow 100

LECTURE.

PART I.

ASTRONOMY is that science, or division of knowledge, which treats of those physical laws of existence and motion which regulate the great masses of the universe termed the heavenly bodies; which explains their mutual relations, their several actual conditions, and the general arrangement and action resulting from their organization.

The word ASTRONOMY, by its derivation, signifies, with ASTROLOGY (with which epithet it was originally coincident), the *reason*, *interpretation*, or law of the ASTRA, or stars. This definition of Astronomy explains to us, at once, the stupendous character of its object, with the high interest and sublimity of its inquiries and speculations. A science which presents to our consideration the greater works of creation, and engages us in the study of their direct manifestations of power, together with the unerring truth and beauty of the laws of action which govern them, will ever hold pre-eminence over other branches of human knowledge.

Of the devices proposed by active ingenuity for the popular dissemination of knowledge, oral instruction, combined with pictorial illustration, is admitted to be the most agreeable and successful, and, therefore, the most popular; and, if the importance and dignity of the science of Astronomy be rightly considered, there will be little hesitation to conclude that ASTRONOMICAL LECTURES, of a character judiciously suited to the genius and previous information of the auditory, may reasonably assume a foremost place in this mode of teaching.

Astronomy, universally acknowledged to be the most sublime and interesting of those sciences which admit of popular illustration, is doubly valuable, from its powerful influence and effects in the refinement and elevation of the human mind, and the vigour it imparts to the higher faculties.

Were astronomical knowledge productive of no other advantage to us, it has rendered essential service to mankind, by at once dissipating our superstitious opinions and fears. Ignorance, naturally timid, and terrified at dangers which it cannot distinctly foresee, seems ever to suspect the constancy of nature, and regards her operations with dread and apprehension; but, once clearly informed of their regularity and invariable order, it is converted into confidence, belief, and admiration. Thus we find that the superstitions of Astrology were eradicated by the truths of Astronomy. The astrologers of old consulted the stars, under the vain pretence of searching into the designs of fate, and the hidden events of futurity; but the astronomer now explores the heavens, for the rational purpose of administering to the wants and necessities of mankind by useful discoveries and scientific applications of the unerring regularity of motion he finds everywhere established.

Astronomy, like every other science, was first studied, as an art subservient to the purposes of social life. The chief object of this art was to know and to mark the progress of the seasons, which depend, either immediately or remotely, on the motions and relative positions of the heavenly bodies; and, accordingly, some knowledge of these has, in every state of society, been a matter of the first necessity. A ready method of marking the seasons seems, in all ages, to have been the chief incitement to the study of Astronomy. It directed the labours of the field, the migration of the shepherd, and the journeys of the traveller. It was equally necessary, to regulate the appointment of public meetings, and for the record of remarkable events. The cultivation of the earth, the whole business of agriculture, depends, in fact, upon a due knowledge of the proper motions of the earth, as regards the apparent course of the sun, and the consequent changes of the seasons. In every climate there are certain intervals between the different operations of agriculture; which, once known by experience, shew the proper point of time at which those operations are respectively to be performed. But to know exactly, and even, as is often required, to know beforehand, the commencement of every season, and its stated continuance, we must be able to search the heavens for those invariable signs which are constantly connected with them, and unerringly announce their recurrence. Such signs, indicated by the position of the sun in the heavens, or by the appearance and position of particular stars—although, from the vast stock of practical knowledge we have already obtained, they are now but little attended to—were yet, in the ancient world, when the cultivator had no other guide to direct his labours than his own simple observations, absolutely necessary for his guidance, and were a condition of his subsistence and prosperity. The presence, at certain hours, of the star Arcturus, the constellation Orion, and the Pleiades, marked out the seasons of the ancient Greeks; and the rising of the star Sirius with the sun, announced to the Egyptians the approaching inundation of the Nile, and thus prepared them for the agricultural operations which immediately followed its subsidence.

In the common affairs of life, nothing is more necessary than an exact measure of time; and, for this, it is to the heavens alone that we must look for a certain and invariable standard. From the order, and the beautiful regularity of the motions of the heavenly bodies, we obtain all our knowledge of the seasons, and the art we possess of reckoning by certain periods of time. While the uncivilized and solitary barbarian computes his seasons by the falls of snow, or the progress of spontaneous vegetation, the astronomer refers to the heavens, and measures the regular lapse of time, and the extent of their duration, with a precision no longer to be doubted. Astronomy affords us invariable and unalterable standards by which we measure *time*, *extent*, and *motion;* all great periods of time are compared with, and estimated by, the greater astronomical phenomena, as its lesser divisions are measured by the oscillations in equal times of the pendulum.

Chronology is a science so intimately and so immediately connected with astronomical observation, that, without the constant assistance and application of Astronomy, the records of history itself would possess little certainty, and the transactions of past ages would have remained to us an undigested mass of doubt. Whole nations have been swept from the earth; their arts and sciences, and even their languages, have been lost; confused and unintelligible masses of ruins alone mark the sites of the mightiest cities, and the monuments of their power and industry; and even their history survives the general wreck but in dark and doubtful tradition: but their astronomical observations are preserved to us; and the perfection of these, while it marks the high antiquity of the observers, fixes with accuracy the periods of their existence, and proves the state of their progress in the science.

But Astronomy affords us advantages of higher interest than even these, and of more immediate importance to the progress of civilization, and the general advancement of the world, in the assistance which it renders to the science of geography, and the art of navigation. Astronomy first demonstrated to us the true figure and circumstances of the planet we inhabit; was mainly instrumental in discovering the detail of its construction; disclosed the nature of its true motion, and fixed its relative position in space: Astronomy it was that first inspired the adventurous mariner with confidence, and taught him to navigate the pathless ocean in perfect security!

Scene No. 1.*—The Fixed Stars.

It is in the grandeur and sublimity of night, when a clear and still atmosphere affords us an undisturbed view of the starry heavens, that we generally receive the first practical lesson in Astronomy, and our first and most permanent impression of its beauty and its usefulness: thus we learn that, in the

* The reader is here supposed to be the lecturer, addressing his auditory.

simplicity of pastoral life, untaught shepherds were the first systematic observers of the more striking astronomical phenomena. It will be perfectly easy for a person, even wholly uninformed on the subject, to conceive that an attentive and frequent observation of this scene would enable him so far to distinguish the most remarkable stars, as to make them objects of ready reference, and even, in some degree, to classify them; forming for himself several striking groups, or configurations, and thus establishing readier and more extended means of observation.

A simple study of this nature, even if carried no farther than a ready recognition of one remarkable group of stars, will afford a first and very satisfactory lesson, leading directly to the clear conviction of an important fact; namely, that the stars are, in reality, not stationary as regards the inhabitants of the earth, but have an apparent and uniform motion from east to west, making, in strictness, one entire revolution about the earth in every twenty-four hours.

If we make our first observation in an open space looking southward, with a rough sketch, or a perfect recollection of a few such remarkable groups, from previous observation, we shall find some one of these *constellations*, as they may now be termed, appearing, or coming slowly into view, in the eastern quarter of the heavens; and, in a path of circular curvature, to attain, at the same slow rate of motion, its point of greatest elevation; when it arrives directly in front of us, or bearing directly south from us, to decline towards the west at the same rate, and to describe equal distances in equal times, until it finally sinks and disappears in the western quarter. We shall also observe that some groups, or single stars, seem to describe larger portions of circles than others: some will rise at the eastern point itself, and, describing a path exactly semicircular, set or disappear at the western point; others, which lie towards the south, and near to that point, will be seen to describe smaller portions, or upper segments of circles, remaining in view a much shorter time, but all of them first appearing on the eastern side of the south, and disappearing on the western side. Everything in this observation will tend to satisfy us that the stars are not stationary in the heavens, but have altogether a slow and uniform motion, in a direction from east to west.

If, on another evening, we take a station looking directly northward, and begin our observation on those groups which lie near the horizon, directly north, we shall soon discover that such groups describe complete circles in their paths; if we fix upon a group, or a remarkable star, higher above the northern horizon than the last, we shall find it will describe a smaller circle, that a group taken still higher above the horizon will describe a circle of yet smaller dimensions; and that proceeding with this examination still farther above the horizon, we arrive at a point of the heavens in which the stars appear immoveable: stars which lie very near to this point will be easily discovered, although the imaginary point itself is not actually marked by the presence of any star. One remarkable star will, however, be found very near to this point of rest, which describes so small a circle that, without very accurate observation, it is difficult to determine its motion; and it is, therefore, usually considered to mark the immoveable centre of all the circular motions I have described: the point thus determined is called the POLE, and appears to the observer the only fixed spot in the visible heavens; all other parts of the expanse seem to revolve on it as their common centre: the single star here spoken of is denominated the POLE STAR.

It will now be easy to imagine an immoveable right line proceeding from this star to the earth at Y (Scene No. 1), and forming what may be termed an axis to the imaginary spherical surface on which the stars seem to be placed, and on which the revolutions we have described are performed. It will be observed that, notwithstanding the perfect continuity of the apparent motion, the relative places of the stars are in no case in the smallest degree changed; any group selected for observation may be seen as a whole in different points of its course, to become inverted to its first position, and, passing through the same degrees of obliquity in an opposite direction, to arrive at the position it occupied at the commencement of the observation, with its original appearance; in every part of its course unerringly presenting the same part of its configurations towards the central or polar star.

If, in this stage of the inquiry, the observer can without difficulty conceive the earth he inhabits to be a vast globe floating in space, or, in more familiar language, in the air that surrounds him, we shall with facility obtain his belief that, from the other side, or what is to him the undermost side of the earth, *another assemblage of stars* becomes visible, similar to that he witnesses on his own. If now he be desired to repeat his early observations from his station of northern aspect, and to imagine the line he lately drew from the polar star to the earth, to be extended directly through the earth's centre, and so forward to its surface on the southern side, he will thus obtain the place and position of a line, which, if prolonged towards the supposed stars of that quarter, will be conceived to point out a spot in the heavens in a southern direction, in which the stars have no apparent motions; and, in conformity with his observation in the northern quarter, wherein he was taught to establish a northern pole star, or central point, he will now distinctly trace the position of a similar point in the southern heavens, which he will call the southern pole; and will perceive that the entire expanse, with its assemblage of stars, above, below, and in every direction, has an apparent motion from east to west, which is performed uniformly in twenty-four hours.

The whole expanse of the heavens, with its stars, may be assimilated to an immense hollow sphere, surrounding the earth, as its centre, at an incalculable distance, having the stars posited on its inner surface, and appearing to rotate with a uniform motion, once in each day and night, on that line through the centre of the earth, as an axis, which was imagined to be drawn from the north to the south pole. Conceiving the earth to float freely, and without apparent support, as a centre, it will now appear that one-half of the expanse is visible from one side of the earth, and the other half from its opposite side. That portion in which the north pole is visible will be called the northern half, or hemisphere; the opposite portion, or that in which the south pole is visible, will be termed the southern hemisphere.

Our first scene exemplifies this lesson: here A B C D represent the earth; A B C its northern hemisphere; A D C its southern hemisphere; H H the observer's horizon; E the northern pole in the heavens; E G the imaginary line drawn from that pole through the earth's centre, and continued on the other side to the southern heavens, establishing a southern pole G; the collection of stars arranged at I K L M N O represents the whole expanse of the heavens, of which I K L is the northern celestial hemisphere, M N O the southern.

Now, as to obtain a view of the south pole G, it is evidently necessary for the observer himself to travel on the earth in a southerly direction, it is evident that, as he advances in that direction, the south pole, which, at the commencement of his journey, is below the horizon, or the extent of his vision, will be gradually approaching the horizon, and that after he has travelled over a certain distance it will become visible to him; and as the line, or axis, imagined to exist between the two poles remains fixed as to its direction, it is equally clear that, in proportion as the south pole G is thus elevated, the north pole E will be depressed. When the progress southward is thus continued until the south pole is raised from its depression below the horizon to the horizon itself, the opposite termination of the axis, or the north pole, will be depressed until it also becomes posited in the horizon, the two poles now respectively pointing out the observer's north and south points in the horizon.

If the appearance of the heavens from this new station be now attentively observed, it will be found that the apparent motion of the stars is still performed about the same axis as before; but that the visible effect is materially different. In every entire revolution, or in the space of every twenty-four hours, the observer will now see the whole assemblage of stars of every part of the heavens: the stars of both hemispheres will pass in succession before him, no portion of them remaining permanently above the northern horizon, or describing entire circles as before; no portion of the southern quarter rising into view for a short period, and then disappearing, or any others remaining permanently below the limits of his observation; every star, in whatever part of the heavens, becomes visible to him in its turn, and each describes in its course a semicircle of larger or smaller diameter, as it is more or less remote from the two poles, or fixed points of the axis of rotation.

If the progress towards the south be continued, the elevation of the south pole will be found to increase, producing phenomena of the same character in the southern hemisphere that were before observed in the northern. Those stars which, in the north, had described complete but small circles, and, consequently, never set or disappeared, will now never rise or appear; while those describing only portions of larger circles, and, rising in the east, set in the west, will now appear during a shorter period than before, and that, in proportion as they are nearer to the north pole; the whole phenomena before observed in the northern hemisphere, will now be, as it were, reversed, and the exhibition before witnessed of the stars in the northern hemisphere, will be repeated by those of the southern; the southern stars which at the first observation on the northern hemisphere, never rose to the view, will now become permanently visible, or never set; the northern stars, which before did not set, will now not rise.

The observer might continue to advance in a southerly direction until he arrived at the point x, where the south pole would be elevated to the centre of his visible hemisphere, or be situated directly above him; in this situation he would see all the stars of the southern hemisphere describe complete circles parallel to his horizon, none either rising or setting; none of the southern stars would disappear, none of the northern be seen; the whole picture would be unchanging, varied only by the circular and parallel movement about him. But if he take his advance northward, in the direction of the pole E, until he arrive at the point Y of the earth, the north pole will now appear directly above him; and the appearances just described of the southern stars from the central southern station at x, will be presented of the northern: its stars will have their apparent motion in the same time as before, describing complete circles parallel to his horizon, without either rising or setting.

An attentive consideration of these points will establish the first general notions of astronomical phenomena. It will be clearly understood, that innumerable stars surround the earth on all sides, at an immense distance from it; that they have an apparent motion from east to west, about the earth as a centre; the period of which, or the time in which any given star is found to return to the place in the heavens it before occupied, is twenty-four hours; and that the rate of their apparent motion is strictly uniform, or describing equal portions of the whole circuit in equal times, *i. e.* one-half in twelve hours, one-fourth part in six hours, one-eighth in three hours, one-sixteenth in an hour and a half, and so on.

The first and greatest difficulty, in the acquirement of distinct and profitable information in Astronomy, is to divest ourselves of our most popular notions; not to be discouraged at the commencement by startling contradictions to appearances established, as we conceive, on the most direct testimony of our senses; but readily to lay aside all hastily-formed opinions, and to adopt implicitly, in their stead, such as are offered us with the support of clear demonstration. A perfectly clear conception of the first principles, and the general circumstances of the science, are of too much importance to the progress of a learner, to be neglected; that mode of teaching its elements, which gives facility to the acquirement of clear first notions, must, therefore, not be considered tedious or unprofitable. If our first impressions be not made with perfect distinctness and accuracy, future inquiry is conducted amidst doubt and perplexity; the study becomes desultory, and the information of weakened character, where it would else have been systematic, substantial, and comprehensive.

In all observations of moving bodies, it requires an attentive examination, to be thoroughly satisfied that precisely the same general appearances may not be exhibited, the same perceptions obtained, and the same opinions distinctly formed, although actually produced by motions of a character entirely different. For instance, let us imagine a person borne along in any vehicle of conveyance, with gentle and equable motion, and without any personal exertion, as in the case of floating in a boat slowly and smoothly down a river; and, for a moment, let us suppose, if possible, that, in this situation, he is insensible or ignorant of the boat's motion, or, that knowing it, he entirely abstracts his attention from the circumstance; intently observing the objects on the shore, he receives a distinct impression that he is himself in a state of rest, and that the shores, and the objects upon them, are in motion in the opposite direction to that in which he is actually moving: in this case, we naturally say he reasons on a false principle as to the effects of the motion which he thinks he perceives in the objects on the shores; he draws erroneous conclusions; and, on becoming aware of the true circumstances of the case, he considers that a deception of sense, which is really an error in judgment. A child so situated for the first time, is frequently in this error. A person unaccustomed to travel at a rapid rate, moving upon a perfectly smooth railroad, in a close carriage, and viewing the objects on the road-side from the window, if he could completely withdraw his attention from the noise of the operation, would still more distinctly observe the apparent motion of objects that are really at rest. He is under the same circumstances if, on board a steam-vessel in rapid motion, he passes ships riding at anchor, having their heads in the opposite direction to that in which he is moving: in this case, he generally imagines the stationary vessel to be passing him with a motion equal to that at which he moves himself.

If such deceptions can so frequently take place on the earth, and within small distances, it is easy to believe that erroneous opinions may be formed concerning those motions of the heavenly bodies which, to our first impressions, seem unquestionable; and, as such errors must necessarily be accompanied by false judgments concerning their causes, it is, therefore, important that an accurate knowledge of those motions should precede every other attempt to investigate them. We must be certain that none of those deceptions, by which we find ourselves so frequently drawn into erroneous conclusions, have actually happened in our first observations in this instance. The most natural proceeding, in order to acquire a satisfactory knowledge of these particulars, is, first carefully to consider the leading and obvious phenomena, and thence to deduce the rules which are to guide our further inquiry.

The examples given sufficiently shew us that optical appearances are not always to be taken in the vulgar or common acceptance, and that our first impressions regarding them, if adopted without examination, will frequently be completely deceptive, and at variance with the truth; and it may, therefore, be allowed that, in this instance, as regards the motion of the heavens, they may possibly be erroneous; and that what appears, upon cursory observation, to be the motion of the *stars*, may really be produced by a corresponding *motion of the earth in the opposite direction.*

It is evident that, in the case of the apparent motion of the stars, either the heavens are in motion, revolving about the earth as a centre once in each twenty-four hours, and in a direction from east to west; or, that the stars themselves are immovably fixed in the heavens, and that the earth rotates on its axis once in the same time, and in the opposite direction to the apparent motion of the heavens, or from west to east. A familiar illustration will make it easy to conceive that, whether we imagine the heavens to be in motion about the earth, or the heavens to be fixed, and the earth to turn on itself, the visible effect to its inhabitants will be precisely the same.

For this illustration, let us suppose a common panoramic picture, which every one knows is painted on a continuous plane, curved cylindrically, and fixed in an upright position round a small platform, or stage, which receives the spectators. Now, if an observer take his station in the centre of this platform, and the picture be conceived to have a slow, equable, and perfectly silent motion around him, he will, at each of its revolutions, find every point of the picture presented to his direct view in succession, and in the direction in which the motion is given, which I will suppose to be from the *left* towards the *right*. I will now imagine the observer still to occupy the centre of the platform, and that, instead of the picture being put in motion as before, it remains fixed, and that the portion of the platform on which he stands is made to turn equably and smoothly round on its centre, in the same time as that occupied by the motion of the picture in the first part of the experiment, but in a reverse direction, or from the *right* towards the *left*. In this case he will see every point of the picture in succession as before; the time occupied in one complete view, or revolution, being the same, the same rate of motion will be exhibited, and the apparent motion of the picture will be performed in the same direction as before, from the *left* towards the *right;* and if, in both experiments, the motions be performed with accuracy, and under such mechanical arrangements as shall prevent the observer from being aware of the changes of motion used in the two experiments, it may be safely asserted that his description of their effects upon his perception and his judgment will be precisely the same in both cases.

The first experiment represents, in fact, the apparent motion which takes place in the heavens under our daily observation; a motion, or progress, from the left towards the right; the second experiment represents the real circumstances of the case, as they exist in nature. Let the picture in both experiments represent the heavens, and the platform the earth, the apparent motion of the picture, in the first experiment, is again produced in the second experiment, by the motion of the platform: so, in nature, the progressive advance of the stars from the east towards the west is but apparent, the appearance being actually produced by *a real motion of the earth in the opposite direction*, or from the west towards the east.

Satisfactory evidence may be adduced of the fact that the heavens are fixed, and that the earth rotates on its axis; but, as such proofs involve practical observations with which an audience may be considered unacquainted, it will be the easier course to explain the truth of the case by more familiar instances. Thus: if we imagine the earth to be stationary, and the heavens to revolve about it, such revolution must be swifter than any motion of which we have any measure—any mode of comparison within the reach of our conception; but if the heavens are believed to be fixed, and the earth to rotate, the rate of motion then required to satisfy the conditions of the problem, becomes perfectly easy of comprehension; we can estimate its probability, and give it an unqualified belief. The familiar exposition of parallel cases in which we might err in our conclusions, a few simple calculations of the consequences of such errors, will, therefore, be sufficient for a first and clear apprehension of the truth.

For instance, let the panoramic picture of our experiments be of the usual dimension, viz. of about 300 feet in circumference, and the central platform of the spectator be of ten feet in circumference; let the spectator be placed at its edge, and the time occupied in a revolution five minutes, or 300 seconds. Now, if the platform rotates on its axis, the spectator will view the whole picture by moving through ten feet in 300 seconds, or at the rate of $2\frac{1}{2}$ inches per second; but if the platform is to remain stationary with the spectator, and the picture so to revolve that, in the same time (300 seconds), he may view every part of it as before, the circumference of the picture must move through 300 feet in 300 seconds, a rate of twelve inches per second; nearly five times the rate of motion required of the spectator in the first instance; the effect on him being precisely the same in both cases. This difference between the rate of motion required for the picture and that for the spectator, although considerable, is easy to understand, and presents little difficulty in the performance; the difference between the cost of the mechanical arrangements to move the platform, and that required to move the picture, is very great, but involves no impracticability.

But let us imagine a picture, the circumference of which is 3000 feet, the platform the same as before, and the time of the experiment still the same; the spectator will view the whole scene, if he be moving himself as before, at the rate of $2\frac{1}{2}$ inches per second; but, if the picture is to revolve before him, so that he may view every part of it in the same time, it will be necessary that its rate of motion be 120 inches per second, or fifty times that required of the spectator, to effect the same end. The mechanical difficulties of such an arrangement evidently amount to almost impracticability. I will pursue this experiment one step further. If the picture, or scene, were of ten times the dimensions of the last, or 30,000 feet in circumference, everything else remaining as before, the spectator, by a rotatory motion of $2\frac{1}{2}$ inches per second, can view every part of the picture in 300 seconds; but, for him to be stationary, and the picture to revolve before him, its rate of motion must be 1200 inches per second, or 500 times the rate required for the platform to produce the same visible effect. It is at once evident that, to give to such a picture that rate of motion, would be mechanically impracticable; and the attempt, as regards the production of effect, palpably absurd.

Now, if we consider the distance of the heavens, and the comparatively insignificant dimensions of the earth, we have then before us an enlarged representation of the panoramic picture, and we arrive at the rational conclusion, that the apparent daily motion we witness, is produced, not by a real movement in the heavens, of inconceivable rapidity, such as our experiments shew it must necessarily be, but by the more simple means, the moderate rate of a corresponding rotatory motion of the earth.

Conclusive argument and demonstrable proof will be adduced on this point in the progress of the lecture; for the present general view it is necessary that we consider as admitted, the earth's actual rotation upon an axis of motion, and in a direction from the *west towards the east*, or, contrary to the apparent motion of the heavens, from the *east towards the west*—and the time occupied in a rotation, twenty-four hours; the heavens, as regards *the stars*, remaining stationary.

In speaking of the heavens, we have hitherto termed its visible objects, in a general sense, stars; but we are now to speak of other bodies in the heavens, of the same general character, and, to the unassisted eye, of the same appearance. We have just determined, by popular experiment, the stars to be fixed bodies in the heavens; but amongst these there may be discovered other objects, which, in our first observations, were, from their similarity of appearance, naturally confounded with the general assemblage, and passed without any particular notice. If, instead of a cursory general observation of the whole collection, we adopted a more accurate examination of the individual objects, it would be discovered that some of these stars, which we before considered merely as members of the whole, and, like the rest, stationary as regards each other, have really an independent motion of their own. Observing the rising, the apparent course, and the setting of some of the greater configurations, we shall find that certain stars, some of which are remarkably larger or brighter than the rest, rise later on successive evenings; and, although still partaking of the apparent daily motion of the heavens from *east* to *west*, do really change their places, as regards the rest of the stars, in a direction from *west* to *east;* or, which is the same as regards the effect, that they seem to move slower than the rest in their apparent daily course from *east* to *west*. It will also be found that these objects thus change their relative situations amongst the other stars, each at a different rate of motion, or what appears to be a retardation; and that, with this different rate of motion, each moves in a path distinct from the rest, and that the part of the heavens in which their paths are traced, is limited to a zone, or band of sixteen degrees in width. The continued change of place of these stars amongst the rest, establishes the fact that they possess a certain independent motion of their own; and the regularity of their appearance to us at precisely established periods, shews their motions to be about a fixed central point, and their paths to be traced in a figure which, by a regular curvature, returns into itself.

For the present we will assume this figure to be a circle, and that there exists a fixed central point about which these motions are performed.

We are now arrived at a stage, in the consideration of the subject, that enables us distinctly to perceive a system of positive arrangement, an order of distribution, and an established regularity of motion, where we had before found the attention fixed simply on the brilliancy of the scene, and the vast scale of the exhibition. We now naturally make for ourselves a new arrangement of the objects before us, marking out distinct paths for further inquiry and observation. Such an arrangement, in its earliest and most simple form, will be made under the following heads :—

First, an immense assemblage of stars of various degrees of brightness, scattered, as it were, through the whole expanse of space on all sides, without any marked regularity of distribution ; and having, amongst themselves, no sensible motion or change of place that we can estimate, by reason, as we naturally conceive, of the immeasurable distance at which we are placed from them. Second, a small number of other bodies, some of which possess superior brilliancy to the mass, without departing from the strict similarity of general appearance, and differing from the former principally in having each an independent motion, measurable by simple observation, and performed constantly in established circular and concentric paths, each returning into itself. Third, we find that the paths of these bodies are uniformly restricted to a small zone, or strip in the heavens, which never exceeds a few degrees ; and that these paths are, therefore, really all comprised within a small space above and below the plane in which we may conceive ourselves to be placed with the earth. Fourth, that the great central point, which is common both to these paths and to the whole assemblage of stars, is the sun.

From the moment a distinct notion is formed of this arrangement, a lecturer can intelligibly speak of the Beauty of the Heavens ; for now, for the first time, the observer is convinced of the immensity of the scene before him, and distinctly perceives that, in the midst of the power it exhibits, there reigns a most perfect and beautiful order. He now feels that some unalterable governing law can alone effect the movement of such masses ; and that the presence of this law in operation, presents the undeniable impress of design. It is from this time that a teacher can, in the full confidence of being clearly understood, expatiate on the Wonders of Astronomy.

We shall now speak of these new objects as *planets ;* their accepted designation. They are ten in number ; in general form they are similar to our earth ;—opaque bodies, having no proper light of their own, but which shine and are visible to us by the powerful light which they receive from the sun. They appear to us with much seeming irregularity ; one or two of them are generally visible to us at one time, placed, as regards each other, in a different order, and at varying distances ; but instances are on record of the appearance of five of the most remarkable of them in the same quarter of the heavens at the same time. They are sometimes seen to eclipse each other, or to pass, apparently, one before the other. Their respective motions, although for the most part regular, and performed in the same direction, from the west towards the east, sometimes appear to be slower than usual; and some among them actually *seem* to move alternately in a forward and retrograde direction.

These peculiarities, and their seeming departure from the strictly uniform movements exhibited by the great body of the stars, will be satisfactorily understood, upon an explanation of their circumstances: as to their comparatively small distances from us; the real motions which they all perform about the sun; the great differences in their respective distance from the sun; and the situation of our earth, which is placed amongst them, and is itself constantly circulating with them about the sun, with its own peculiar rate of motion.

The first and great distinguishing character of the planets is, that they have a real motion about the sun, as a centre, while the other stars remain stationary. The next, that their respective distances, as well as their rates of motion, are strictly measurable, and are, therefore, accurately known to us; and further, that their comparatively small distances from the earth place them distinctly within the reach of telescopic observation, and we are thus enabled to determine their dimensions and bulk, their several peculiarities of construction, and a general similarity of condition with the earth, and with each other.

The motion of the earth upon its own axis must be already sufficiently evident, without further explanation: this is termed its diurnal or daily motion; and it is that which produces the alternations of day and night, and the general appearances we have already considered. But we have now another actual motion of the earth to describe; this is a real progress made in a path about the sun as a centre, in common with the planets just spoken of. The earth's rotation on its axis produces the phenomena of day and night; its other motion, that of revolution about the sun, produces the phenomena of those great changes of seasons, which we designate summer, autumn, winter, and spring. This motion of revolution is termed the earth's annual motion, from the period of its performance, which constitutes the space of time we designate a year.

The proofs of the earth's revolution about the sun are obtained from appearances in the heavens, in nearly the same manner as we obtained the proofs of its motion on its axis; for, as the sun does but appear to vulgar observation to move round the earth from east to west, and that appearance is shewn really to arise from the daily rotation of the earth upon its axis in a contrary direction, so the sun does but appear to have an annual motion in the heavens, by its rising and setting in different points of the heavens at different seasons. This last motion is, like the first, but apparent; and is occasioned, really, by a progressive motion of the earth in a path round the sun, which it completes annually.

To distinguish clearly, in description, the collection of planets, the circumstances that govern their motions, and the phenomena they exhibit, from the unlimited assemblage of the fixed stars, we will now term that collection The Planetary System, and proceed to explain its arrangement in detail.

Scene No. II.—The Earth: its Form, and Position in Space.

Independently of the great interest we must take in such inquiries as lead to an accurate knowledge of the body on which we live, it is highly important to a clear understanding of its true nature, and the operations of the planetary system, that we make ourselves perfectly acquainted with the circumstances and the position of our earth, which is itself a member of that system; and, for us, holds the important place of the station, or observatory, whence we view and estimate the phenomena and evolutions of the whole.

In the early ages various fanciful and absurd notions prevailed respecting the figure of the earth; some of which were adopted because they appeared to agree with the vague and inaccurate observations of the uneducated, whilst others were accepted, simply because they accorded with the preconceived and general opinions of the time. The most extensive belief was, that the earth was a vast circular plain, spreading on all sides to an infinite distance; that the space above us, in which the heavenly bodies seem to move, was at no great distance from the earth; and that the stars, with the sun and the moon, existed but for its accommodation and ornament. But, with the progress of learning, and the introduction of the true methods of conducting philosophical inquiry, modern astronomers have arrived at more rational conclusions; demonstrably just, satisfying every condition of the problem, and agreeing perfectly with the most refined observation.

A little reflection, and a reference to common and well-known appearances observed in travelling, either by sea or land, readily convince us that the earth is of spherical or globular form. Let a person take any station in a level country, or at sea, and carefully observe the objects within the range of his view; let him then advance in any direction, and, as he moves forward, the objects behind him gradually disappear, and new objects in his front come in view. If his advance be extended to the distance of a few miles in the same direction, he finds that the objects which were at first visible to him are lost to his view, and that he is now in the centre of a new range of view, or horizon; and so on in every successive point of his progress. Now, as the same changes take place precisely in the same manner at every part of the earth, and with any direction we can take for such an experiment, it must be inferred that the earth is a rounded or spherical body. The same inference is deduced, when we observe from the shore the appearance of a ship at sea; or from the ship, if we observe the gradual apparent rising of the coast as we approach the shore. In the former case, the top of the highest mast is first seen as the vessel approaches the land, the lower masts gradually come into view, and as she continues to advance towards us, the entire vessel becomes visible; the progress of the exhibition being an apparent gradual rising of the object. So, in viewing the land from a ship, the tops of distant hills are first discovered, by degrees we see lower portions of them, and finally their bases, and the face of the country.

The scene exhibits these effects, where the figures of the ships are shewn to become respectively more and more curtailed in their apparent height above the surface of the sea, as their distance from the spectator increases. Of the distant ship he sees only the upper parts of the masts; of the next nearer to him he sees the lower parts of the masts and rigging; but of the ship at the nearest point of distance, he sees, not only the masts entirely, but the hull of the vessel itself, down to the surface of the water on which it floats, together with that portion of the surface which lies between the object and himself; of the ship more remotely placed, he sees nothing. These are appearances which can only be reconciled by assuming a spherical figure for the earth. The same conclusion may be drawn from observing the altitude of the pole star at different stages of a considerable journey towards the north or south. In travelling northward its altitude is increased; in travelling south, it is diminished. Further proof of the spherical form of the earth is obtained from its shadow in an eclipse of the moon.

But the most popular proof of the rounded figure of the earth is obtained from the well-known fact, that navigators have actually sailed *round it;* not on an exact circle it is true, because the irregular figure of the shores does not admit of such a course, but by keeping the direction at first assumed, as nearly as accidental interruptions allowed, they have uniformly arrived at the port from which they departed. Drake, Anson, and Cook, are familiar to all readers, as circumnavigators; those who, in the common mode of expression, "performed voyages round the world." Some of these have sailed in an easterly direction, others in a westerly, and we find that each, by keeping the same general course, has again arrived at the point of departure; and that they all, in the progress of their voyages, observed the phenomena now described, and thus confirmed the opinion that the earth is of a spherical form.

Although these observations, respecting the figure of the earth, afford sufficient evidence that its surface is curved, and its form of globular character, yet none of them determine scientifically, or entitle us to infer, that it is a *perfect* sphere. It was natural for those who first discovered that the earth had, to our common observation, a character of sphericity, to suppose that its form was spherical in perfect strictness. This, however, is now known not to be the case; the true figure being that of a sphere, in a small degree flattened at the two poles, or what is termed an oblate spheroid.

Scene No. III.—The Earth: its true Figure and Dimensions.

In this scene, the solid figure in the centre represents the earth, on which the line A B, drawn through the picture, points out the north pole at A, and the south pole at B. If, therefore, we imagine the line A B to be continued through the earth, it will represent the earth's axis of rotation. The line C D indicates G and H on the body of the earth, as points which, being equi-distant from both the poles A and B, give occasion to term the circle C G H D, which passes through the points C and D, the equator. The eye may not, at once, perceive, that the coloured figure, which here represents the earth, is not perfectly spherical, but departs from the spherical figure, or is flattened at the poles, at A and B. This is a representation of that figure which has been already described as that of the earth. The circular line passing round the solid figure, touching it at C and D, and leaving it at A and B, shews the quantity by which it differs from perfect sphericity. This may be taken as a representation, in principle, of the actual condition of the earth. Its diameter C D at the equator exceeds its diameter A B at the poles. The polar diameter A B is determined to be 7899 English miles; the equatorial diameter C D $7925\frac{1}{2}$ miles; the difference between them, being $26\frac{1}{2}$ miles, shews us that the equatorial portions of the earth, or those situated on the circle C G H D, are $13\frac{1}{4}$ miles more distant from the earth's centre, than the portions at the poles A and B.

To measure the earth, with the view to determine its figure and magnitude, seems, at the first proposition, an enterprise too vast for the utmost stretch of man's power and ingenuity; but happily, in scientific pursuits, difficulties only incite the diligent to more active exertion; and the philosopher, instead of being depressed by a feeling of inadequacy to the task before him, applies his intelligence to the resources of science, and accomplishes with ease what seemed to his natural powers altogether impracticable. This applies, in a very striking manner, to the mensuration of the earth. Towards the end of the seventeenth century, a French astronomer found, in the course of some observations, that the pendulum of his clock made its vibrations more slowly near the equatorial diameter of the earth than in Paris; and that it became necessary to shorten it considerably, in order to make it agree with the periods of time indicated by the stars.

The natural sciences were not then cultivated to the extent they are at present; and it now appears to us equally curious and delightful, that a circumstance so simple and so trivial in its first appearance, should have elicited consequences of a nature so extensively important.

The first observation of these unexpected phenomena was industriously followed up; and it was not long before the subject engaged the laborious attention of Newton, and of all the leading philosophers of the age. From their researches resulted the determination of the earth's precise form and magnitude, and the incontrovertible proof of the extent and the laws of the power we term gravity, which, by the subsequent refinement of the science of Astronomy, is determined to be the unlimited governing power of the entire planetary system.

The process of submitting the earth to an actual mensuration, may be thus familiarly described.

To enter into the calculations employed in this inquiry, would be inconsistent with the nature and intention of a familiar lecture; the principles upon which they are founded are simple, and perfectly easy of comprehension.

It is the known property of a pendulum, that its vibrations, when made in small arcs, are, at the same place on the earth's surface, performed in the same time; and that the period of time in which each vibration is made, bears a certain and known proportion to the length of the rod or line to which the weight of the pendulum is attached. Thus, in London, a pendulum of $39\frac{1}{8}$ inches in length makes each vibration in one second of time; one of $9\frac{3}{4}$ inches makes its vibrations in half a second: the shorter the pendulum, the quicker are its vibrations; the longer it is, the slower is its motion.

But the time in which a pendulum of any given length performs its oscillations, depends, not only upon the length of that pendulum, but also upon the intensity of a certain force which attracts or impels it towards the earth. We know familiarly that there exists a force, or power, of this nature, and that it is universal and constant in its action; for we see an illustration of it in the tendency of all bodies to fall to the ground. That property by which bodies give evidence of being heavy, is called GRAVITY; the expression is derived from the Latin, *gravis*, heavy; while the body falls or moves towards the earth, it is said to *gravitate*. It is correctly ascertained, that the rate at which a given body gravitates, or the period of time it occupies in its fall to the earth, varies in a known proportion with its distance from the earth's centre; the more remotely the falling body is situated from it, the slower will be the rate of its gravitation, and *vice versâ*. A pendulum oscillates by reason of a continued effort to fall, made by its plummet; it gravitates; and, being held by its rod, or line, it moves on afresh in the opposite direction, and rises by the impetus it acquired in its descent; the force of the impetus being expended in the rising motion, the plummet again gravitates, and so on, repeating its oscillations by the unintermitting power of gravity. If the force of gravity, which produces this motion, be diminished by any cause whatever, the pendulum, having less tendency to motion than before, will require a longer time to move through the same space; and, therefore, in order that the vibrations may still be made in the same time as before, the length of the rod must be shortened; by this a new velocity will be given to it, sufficient to compensate for the deficiency in the power of gravity.

This was exactly the case, in the first experiment made near the equator: the observers found it necessary to shorten the rods of their pendulums, in order to make them perform their vibrations in the same time as in Paris; and from this it was correctly inferred, that gravity, which produces the action of the pendulum, was actually lessened.

But what was the cause that rendered gravity less powerful at the equator than at Paris? This is the question upon which everything relating to the subject depends. Newton viewed it in the following manner:—The diurnal rotation of the earth is performed round the imaginary line A B, which passes through and between the two poles; and as the equator C G H D is farther distant from the centre than any other circle which is parallel to it, it is evident that those parts of the earth which are situated on the equator, do actually move with a greater velocity than those which are nearer to the poles; and, by their incessant tendency to move farther from the centre, the equatorial regions have become somewhat more elevated than the polar regions.

This tendency of bodies to fly off from the centre round which they move, is termed the *centrifugal force*, the nature and existence of which may be rendered evident in various ways. As, for instance, when a stone is whirled round swiftly by means of a sling, the arm feels itself stretched by a force which is exerted upon it by the stone, in its effort to fly from the centre; and if, by any means, the stone be disengaged from the sling, it will instantly exhibit the tendency it has to leave this constrained circular orbit, by proceeding directly forward in a straight line.

Besides this, there is another force, which is termed the *centripetal force*, being so called because it is directed towards the centre, and acts in a direction opposite to the former. This force, in the present case, is the same as gravity. All bodies, when left to themselves, fall to the earth in straight lines, which are perpendicular to its surface; and if those lines were continued, it is evident, from the figure of a globe, that they would all pass through the earth's centre. Every part of the earth, therefore, gravitates towards the centre; and this gravitating force is determined to be about two hundred and ninety times greater than the opposite or centrifugal force, or that which arises from the rotation of the earth upon its axis; a certain balance is, therefore, constantly maintained between them, and the earth assumes the spheroidal figure which naturally results from the difference of these two contrary and opposite forces.

The learned disquisitions entered into, as to the cause of the earth's irregularity of figure, were followed by the invention of methods of actual measurement, in order to confirm the deductions made from the laws of gravity, giving us the results already mentioned.

It is known that a circle, of whatever dimensions, is, for the purposes of calculation and angular measurement, supposed to be divided, on its circumference, into 360 equal parts, termed degrees. In the scene, the outer circle E F K L of the figure may represent the circular expanse of the heavens about the earth. Half of this expanse, as the semicircle E F K, will represent the portion of the heavens visible from any part of the earth at one time; this will, therefore, contain 180 of the divisions, or degrees. As all circles, without reference to their extent, are divided in the same manner, the outer edge of the earth (supposing the earth to be spherical) will also contain 360 degrees; and it becomes evident that, from each portion of one degree in the heavens, we can derive a corresponding space on the earth immediately beneath, which will constitute the measure of a 360th part of the earth's circumference. It is evident that if the earth were a perfect sphere, the line of its circumference would be perfectly circular; that a 360th part of the whole, or one degree, derived from the heavens, would be of the same length at the equator C and D, as at the poles A and B; and that such divisions would, on every part of the earth, be perfectly equal. The discovery of the unequal action of the pendulum led, however, to well-grounded doubts whether this were actually the case: the great importance of the question at length produced the determination to measure a given number of degrees, both at the earth's equator and at its poles, or at places so nearly approaching these points as to exhibit distinctly the difference of length between them, if any difference did exist. These great operations were undertaken by different European governments, and were performed with the utmost care, and with the aid of the most excellent instruments, by persons eminently qualified for a task requiring accuracy of observation, and the measurements have been made, at different periods, on various parts of the earth, both in its equatorial and polar regions. In India, in Peru, on the continents of Africa and America, in France, in England, in Italy, in Russia, and in Lapland.

It is from the most careful examination and comparison of these measurements, that the earth's actual figure and dimensions have been finally determined. The diameter at the poles, or A B of the scene, being 7,899 English miles; the diameter at the equator C D, 7,925½ miles; leaving a difference of 26½ miles.

Scene No. IV.—The Planetary System.

The form and character of the earth, being thus understood, a general view of the collection we term the planetary system is rendered more distinct and easy of comprehension. The order and arrangement of the bodies composing it, the motions which they respectively perform, and the collective effect of the whole, constitute the system.

It may be thus generally described:—The sun, as the central body of all the celestial motions, about which the earth revolves, in a path nearly circular, and at a distance of several millions of miles. Within this path, or orbit of the earth, two other planets, Mercury and Venus, move in orbits of the same character, at different distances; Mercury being the nearest to the sun, and Venus between Mercury and the earth, at a greater distance from the sun. On the more distant side of the earth's orbit, as regards the sun, or, as it were, on the outer side of it, the planet Mars revolves, distant from the sun somewhat more than once and a half the earth's distance. Next, beyond Mars, move four very small planets, Vesta, Juno, Ceres, and Pallas, each moving in a distinct orbit, at distances from the sun not greatly differing from each other, and at nearly three times the earth's distance. Beyond these small planets, and at upwards of five times the earth's distance from the sun, the planet Jupiter moves in his orbit. Beyond Jupiter, at nearly ten times the earth's distance from the sun, moves the planet Saturn; and again, on the outer or farther side of the orbit of Saturn, the planet Herschel or Uranus moves in an orbit of the same character as the rest, and at a distance from the sun of nearly twenty times that of the earth.

Of these ten planets, five have been known from the earliest ages, and are so conspicuous as to be clearly visible to the naked eye: these are Mercury, Venus, Mars, Jupiter, and Saturn. The other five, *viz.* Vesta, Juno, Ceres, Pallas, and Uranus, have been discovered within the last sixty years, since the modern improvements in the telescope, and are visible only by telescopic assistance, with the occasional exception of Vesta.

Besides these, there are a number of other, and much smaller planets which circulate about some of the larger, and are, on that account, termed the satellites of their respective planets. The larger planets are distinguished by the term *primary planets;* the smaller, or satellites, are termed the *secondary planets.* The moon is, therefore, considered a satellite, because it circulates round the earth. When speaking of the planets, as we view them from the earth, I have stated the number to be *ten;* but, in a general view of the entire planetary system, we contemplate the whole at once, and include the earth; their number is, therefore, actually *eleven.* Of these, the planets Mercury and Venus, whose orbits are within that of the earth, or nearer to the sun, are termed the *inferior* planets; those whose orbits are without that of the earth, or more distant from the sun, are termed the *superior* planets.

The scene exhibits a general view, or a plan of the arrangement I have described, as regards the seven principal planets—*viz.* Mercury, Venus, the Earth, Mars, Jupiter, Saturn, and Uranus; the four small planets, Vesta, Juno, Ceres, and Pallas, are, for greater perspicuity, displayed in another scene.

In this scene, the sun is seen in the centre. The small circle, immediately surrounding it, represents the orbit of Mercury, the planet nearest to the sun; the circle next beyond this shews the orbit of the planet Venus; then the Earth, with its satellite, the Moon; next, the planet Mars; beyond this is placed Jupiter; next, Saturn; and, far beyond Saturn, we see the planet Uranus, the most remote known body, of the planetary character, in the system. The colouring of this scene is so arranged as to assist its perspicuity. It will be observed, that the space which occupies the centre, or around the sun, is coloured blue; this space includes the planets Mercury, Venus, the Earth, and Mars. Between Mars, the outermost of these planets, and Jupiter, the next beyond him, the intervening space is of considerable breadth; this, for clear distinction, is coloured yellow, and is to be particularly observed, as containing within its extent the orbits of the four small planets, Vesta, Juno, Ceres, and Pallas. Beyond the orbit of Jupiter, the remaining space is coloured violet; and contains within it the orbits of Saturn and Uranus, as before described. The dotted lines, which traverse the scene, represent the paths of comets, which will be particularly described hereafter. The following scene, No. V., is auxiliary to the present, and is intended to shew the inner space of this scene on a larger scale.

Scene No. V.—Mercury, Venus, the Earth, and Mars.

This scene, which is to be considered explanatory of the last, exhibits more distinctly the orbits of Mercury, Venus, the Earth, and Mars, which occupied the centre of the last scene; the space they occupy is coloured blue as before. The order of these planets, in their proximity to the sun, I have already described. First, Mercury; second, Venus; third, the Earth; fourth, Mars. The scene beyond the orbit of Mars is coloured yellow, as in the last scene, and here denotes the beginning of the space which is occupied by the four small planets, Vesta, Juno, Ceres, and Pallas.

Another auxiliary scene will shew us the orbits of these four planets on a still larger scale, and enable us to understand some extraordinary particulars in which they differ from the larger planets.

Scene No. VI.—The Earth, Inferior Planets, and the Asteroids Vesta, Juno, Ceres, and Pallas.

This scene affords a further explanation of both the foregoing. It exhibits the portion of the last scene, containing the orbits of the four small planets, on a still more extended scale. It is coloured yellow, as before, from the orbit of the planet Mars to that of Jupiter, which is also marked by the commencement of the violet tint, as before. The central object, here, is the Sun; the object nearest to the sun, within the blue circle, is Mercury; the next is Venus; then the Earth; and next Mars. In the yellow space between the orbits of Mars and Jupiter, the first of the four small planets, or that nearest the sun, is Vesta, marked v; the second in order of distance from the sun, is Juno, j; the third, Ceres, c; the fourth, Pallas, p.

We will now consider the nature and circumstances of each body composing the system, beginning at the centre, with the sun. This scene illustrates the subject as far as the orbit of Jupiter inclusive.

For many ages the sun was believed to be simply a vast globe of fire; but the astronomers of modern times have rejected this opinion, as unsupported by any philosophical hypothesis, or by sufficient observation. It is now uniformly concluded, that the sun is a large planet of globular form, generating within itself, and dispensing, on every side, the light and heat with which all nature is supplied. It was supposed by Herschel, and other eminent astronomers, that the actual body of the sun was itself opaque, but surrounded by matter of luminous character, or of a nature to produce the phenomena of light and heat. The learned and philosophical have been much divided in their opinions as to the precise nature of the sun's heating power; but that the sun is the source of the light which extends over the entire planetary system, and the cause of the heat which maintains the productive powers of nature, by whatever particular process these phenomena are produced, the scientific and well-informed universally agree, and the most unlearned are convinced.

The received opinions as to the character of the sun's composition, are illustrated in a distinct scene.

In a first and familiar statement of the distances, magnitudes, and motions of the bodies composing the system, in every case the nearest approximate numbers will be given, simply because they are more easily retained in the memory; minute exactitude is deferred to an advanced stage of the lecture, when it becomes more essential.

The diameter of the Sun is computed to be 886,000 of our miles; and it has a movement of rotation on its own axis, once in twenty-five and a half of our days, nearly in a direction from west to east.

The actual motions of the other planets will be more clearly understood, if, referring to the scene before us, we now imagine ourselves placed at its centre as a station of observation.

The nearest planet to the sun is Mercury: his distance from which is computed to be 37 millions of miles, and his diameter 3,224 miles; he has a movement of rotation on his own axis, in a direction from west to east, in a little more than twenty-four hours; and performs a revolution about the sun (also in a direction from west to east) in about eighty-eight days; moving, in this orbit of revolution, at the rate of 111,500 miles in each hour.

The second planet, in point of distance from the sun, is Venus: her computed distance from it is nearly 69 millions of miles, and her diameter 8,648 miles. She has a rotation on her own axis, in a direction from west to east, in twenty-three hours and a half of our time; and performs a revolution about the sun in 224 days and 17 hours nearly; moving in her orbit at the rate of more than 80,000 miles in each hour.

Our Earth is the third planet in distance from the sun. Of the earth, I need only observe, at present, that we are somewhat more than 95 millions of miles distant from the sun; that the earth has a rotation on her own axis in twenty-four hours, in a direction from west to east; and performs a revolution about the sun in 365 days, 6 hours, and somewhat more than 9 minutes; moving in her orbit at a rate of about 68,000 miles in each hour.

The Moon, although not a primary planet, but a secondary, or satellite to our earth, is to us the most remarkable of all the subordinate heavenly bodies: she is particularly distinguished by her periodical change of figure, and the consequent variation of her light. The moon is situated at a comparatively small distance from the earth, and constantly accompanies it in its revolution about the sun, revolving round it nearly in the same manner as the earth itself circulates about that luminary. The distance of the moon from the earth is only 240,000 miles; her diameter is nearly 2,180 miles; she revolves about the earth, in a direction from west to east, in twenty-nine of our days, and nearly thirteen hours, and has a motion of rotation on her own axis in a contrary direction, and performed in the same time. To estimate the rate at which the moon travels round the sun, it must be considered that she has a two-fold motion—one of revolution about the earth in twenty-nine days and thirteen hours, and another, also, of revolution about the sun, by constantly accompanying the earth in her revolution about the sun. In her orbit round the earth, the moon moves somewhat more than 2,100 miles in each hour; while, in her joint revolution about the sun with the earth, she also moves with the earth, and effects, by this compound revolution, a progressive motion of about 76,000 miles per hour.

The fourth planet from the sun is MARS, marked M in the scene, on the verge of the blue tint. The computed distance of Mars from the sun is 145 millions of miles. His diameter is nearly 4,431 miles; he has a motion of rotation on his own axis in twenty-four and a half of our hours, and performs a revolution, in his orbit about the sun, in about 687 of our days, or nearly one year and eleven months of our time; moving in his orbit at the rate of more than 55,000 miles in an hour.

The fifth planet in order from the sun, is a small planet discovered in the present century; it is called VESTA, and is marked V on the scene. The distance of this planet from the sun is determined to be nearly 225 millions of miles. Neither its diameter nor the rotation on its axis are yet accurately determined; but it is supposed to be considerably smaller than the rest. It performs a revolution about the sun in 1,369 of our days, or three years and three quarters.

The sixth planet in order of distance from the sun, is also a small one of recent discovery. It is called JUNO; it is shewn on the scene at J. Its distance from the sun is computed to be 254 millions of miles, and its diameter about 1,400 miles. Its motion of rotation is not ascertained; it performs a revolution about the sun in 1,588 of our days, or 4 years and 128 days.

The seventh planet from the sun is CERES, marked in the scene C. This is, like the two last mentioned, of modern discovery. Ceres is 263 millions of miles distant from the sun; its diameter has not been accurately ascertained, but is supposed not to exceed 170 miles; it makes a revolution about the sun in 1,660 of our days, or four years and nearly seven months.

The eighth planet from the sun is PALLAS. This is also a small planet discovered in our own times. Pallas is shewn on the scene at P. This planet is somewhat more than 263 millions of miles distant from the sun; its diameter and motion of rotation are yet unknown to us; it performs a revolution about the sun in nearly the same time as Ceres—1,660 days, or four years and nearly seven months.

In this general view of the system, it is essential to distinctness of description to speak of these four planets in the order of their distance from the sun. I shall presently consider them in the order of the dates of their discovery.

The ninth planet in order of distance from the sun is JUPITER; it is shewn on the scene at J, beyond the yellow tint, and on the verge of the violet. Jupiter is much larger than any other planet of the system; and is the first beyond our earth that has any secondary planets, or satellites, revolving about it. His distance from the sun is somewhat more than 494 millions of miles; his diameter is nearly 90,000 miles. He has a prodigiously rapid motion of rotation on his own axis; he makes one rotation in nearly ten of our hours; and performs a revolution about the sun, in his orbit, in somewhat more than 4,332 of our days, or nearly twelve years, in a direction from west to east like the rest.

The planet Jupiter is accompanied by four satellites, which are of different diameters, and revolve round him at different distances, and with different rates of motion. They are opaque bodies like all the other planets.

The distance from Jupiter of his first or nearest satellite, is 256,500 miles; and it performs a revolution about the planet in forty-two of our hours.

The distance of the second satellite from Jupiter is 432,000 miles; it makes a revolution about the planet in eighty-four of our hours.

The third satellite is 690,000 miles distant from the planet, and makes a revolution about it in 172 hours.

The fourth satellite is 1,015,000 miles distant from the planet, and performs its revolution about it in 400 of our hours.

These satellites are of very different magnitudes; some of them being larger than our earth, while others are not so large as our moon. It has been found impracticable to measure their real magnitudes with any tolerable degree of accuracy. It is, however, ascertained, that the third in order of distance from the planet is the largest; the first in order of distance the smallest; while the fourth in distance is not quite half so large as the third, and the second in distance is about one-fourth as large.

The tenth planet in distance from the sun is SATURN (see Scene IV.). This planet presents a magnificent and unparalleled appearance in the heavens. Saturn shines with a very feeble light as compared with Jupiter, on account of his greater distance from the sun; but, notwithstanding this, he is the most extraordinary and engaging object which Astronomy presents to our view. Saturn is distinguished from all the other planets by a broad luminous ring, which is situated at a considerable distance from his body, and completely encompasses him. The breadth of this ring is about one-third of the planet's diameter; and the distance of its inner edge from the body of the planet is nearly its own breadth. We shall consider the peculiar circumstances of this planet more particularly in another scene.

The distance of Saturn from the sun is somewhat more than 906 millions of miles; his diameter is computed to be about 79,000 miles. He has a motion of rotation on his own axis in ten and a quarter of our hours nearly, in a direction from west to east; and performs a revolution about the sun in about twenty-nine and a half of our years.

Saturn is attended by seven satellites, whose distances from the primary planet, and the times of their revolutions about him, are accurately observed: their actual diameters have not been ascertained.

The distance of the first satellite, or that nearest to the planet, is about 132,400 miles; it performs a revolution about Saturn in a little more than twenty-three hours and a half.

The second satellite is at nearly 170,000 miles from the planet, and makes a revolution about it in nearly thirty-three hours.

The third is at 209,000 miles distance, and makes a revolution about it in forty-five hours.

The distance of the fourth is nearly 270,000 miles, and the period of its revolution sixty-six hours.

The fifth satellite is at 376,200 miles distance, and it makes its revolution in four days and twelve hours.

The sixth is at 872,200 miles distance, making its revolution in sixteen days.

The seventh, or most distant satellite, is at upwards of two and a half millions of miles from the planet, and makes its revolution in nearly eighty of our days.

The eleventh, and most remote known planet of our system, is Uranus. Its distance from the sun is 1,800 millions of miles; its diameter is about 35,000 miles; and it performs a revolution about the sun in a little more than eighty-four of our years. It is accompanied by six satellites. The period of its rotation on its own axis is not accurately known; but it is conjectured by the best authorities, that the movement of rotation of this planet is not less than that of Jupiter and Saturn.

The satellites of this planet have some remarkable peculiarities, which will be explained in another scene.

The planetary system also includes another class of bodies, essentially distinct from the planets, and differing from them in all the leading features of their constitution, their order of arrangement, and the character of their motion about the sun: these are the bodies we term Comets.

Comets, although permanent bodies, appear to us but occasionally, and, in many instances, without any established regularity that we can estimate; while, in other cases, the periods of their appearance are clearly ascertained. This uncertainty arises simply from the circumstance of comets moving in orbits of a form entirely different from that of the planets. These latter move in orbits nearly circular; but the orbits of comets are, for the most part, ellipses of great length, and comparatively small breadth, in which they move about the sun, as the planets do, in their respective paths; but in the case of a comet, the sun is not situated in the centre, or middle, of its orbit, but near to one of its extremities; and the nearer, in proportion to the narrowness of the ellipsis, or the disproportion, as it may be termed, between its length and breadth. Under these circumstances, a comet, while travelling in one portion of its orbit, moves within the visible limits of our planetary system, or the orbits of the planets; and in other portions of its orbit it travels far beyond the limits of these orbits, and, consequently, very far beyond our sight. Accurate observation, however, on one portion of these elliptical orbits, enables us to determine the character and dimensions of the whole; and we can, therefore, estimate the period during which a given comet must remain invisible to us, and safely predict the time of its re-appearance.

Comets are seen to traverse the heavens in all parts, and in every direction. They are visible to us only when in that portion of their orbit which is nearest to the sun, but invisible when in the other part. There are even some which have appeared to move in a curve of a different character, *viz.* the hyperbola; in which case the comet, once visible to us, soon after vanishes from our sight *for ever*, to move in boundless space through remote regions of the universe, of which we know nothing—to distances, of which we can form no conception.

Comets, when in the visible part of their orbits, move with prodigious velocity. The most remarkable comet on record, that of the year 1680, was estimated to move at the rate of 880,000 miles per hour.

Comets are generally accompanied by a train, or stream of light, which, for want of a more distinct expression, is termed its tail.

Though so well acquainted with the motions of comets, we know nothing of their physical constitution; the greater number appear only like clouds, or masses of luminous vapour, and often without any appendage, or tail. Such have been many of the comets which have appeared within the last forty years; but they commonly seem to consist of a mass of dim light, like a planet surrounded by a very transparent atmosphere; the whole being so thin and clear that the smallest stars may be seen through the most dense part of them, even when examined with a telescope.

The great importance of comets in the planetary system, as regards their estimated numbers, may be conceived from the accredited statements, that more than seven millions of comets, in one part of their orbits, pass through the orbits of our planetary system.

We have thus a general view, or what may be termed a rapid sketch, of the great planetary, or solar system; which enables us to examine the bodies that compose it, separately, and in detailed description.

A simple tabular statement of the distances and magnitudes described in this view, will impress them more distinctly on the memory, and be of easier reference.

The sun occupies nearly the centre of the entire system; is 886,000 miles in diameter; and rotates on its axis in twenty-five days and a half.

Names of the Planets.	Distances from the Sun in Miles.	Diameters in Miles.	Revolutions in Orbits.			Rotation round their own Axis.
			Years.	Days.	Hours.	Hours.
Mercury....	37,000,000	3,224	,,	88	,,	24
Venus.......	69,000,000	8,648	,,	224	17	23½
The Earth..	95,000,000	7,912	1	,,	,,	nearly 24
Mars.......	145,000,000	4,431	1	322		24½
Vesta......	225,000,000	unknown	3	274	,,	unknown
Juno.......	254,000,000	1,400	4	128	,,	unknown
Ceres......	263,000,000	170	4	200	,,	unknown
Pallas......	263,000,000	unknown	4	200	,,	unknown
Jupiter.....	495,000,000	90,000	11	315	,,	nearly 10
Saturn......	907,000,000	79,000	29½	,,	,,	10¼
Uranus, or Herschel	1800,000,000	35,000	84	,,	,,	unknown

Before we quit this rapid view of the planetary system, it will be necessary to make a little extension of the general terms, in which, for simplicity of description, its forms of arrangement, dimensions, and movements, have hitherto been spoken of.

For conciseness we have hitherto spoken of the planets as moving in circular orbits, and described the planets themselves as being of a spherical form. As we advance, however, it is necessary gradually to extend our views on these points. It must now be understood that the planetary orbits are, in strictness, *ellipses;* not, it is true, differing greatly from circles, but still they are decidedly of an elliptical form. In like manner it should now be explained, that the figure of each planet is not, in strictness, spherical, but is, in every instance, more or less *spheroidal*, as that of the earth; a diameter, measured from pole to pole, being somewhat less than a diameter measured through the equator. These differences will be accurately stated, as we successively examine the detail of each planet.

It must also be clearly understood, that all the planets, as well as the sun itself, rotate in a direction from west to east, on axes that remain nearly parallel to themselves in every part of their orbit, and with velocities, respectively, that are sensibly uniform. As the planets rotate on their axes in a direction from west to east, so they also perform their respective revolutions about the sun, in the same direction; and, further, as the primary planets themselves move round the sun from west to east, so do the satellites of each move round their respective primaries in the same direction.

The portions of time spoken of, with reference to the movements of the earth and planets, must be understood to be all derived from some undeviating phenomenon in nature, to which we can at all times refer for proof, if necessary, of an accurate reckoning: as, for instance, the portion of time we term a year, is established by the earth's performance of a complete revolution about the sun. What we term a day, is, properly speaking, a day and night, or the time in which the earth performs a complete rotation on her own axis. The hour is simply a subdivision of the day and night into twenty-four parts; the minute, a lower subdivision of the hour into sixty parts; the second, a subdivision of the minute also into sixty.

In astronomical inquiries, besides these, our simplest divisions of time, astronomers employ two other measures of time, for a year: one termed the *tropical year*, the other the *sidereal year*. These accurate distinctions will be explained hereafter. It will be recollected that, at present, we are making a rapid examination of the subject, with approximate numbers and quantities only. The year regulating the business of common life consists of 365 days 6 hours; being nearly a mean between the tropical and the sidereal year of astronomy.

With this general knowledge of the entire planetary system, we are now qualified, in point of information, to examine the individual members composing it, and to inform ourselves of such of their respective peculiarities as have been discovered in modern times by telescopic observation.

In the view we have just taken of the system, we have looked at the entire arrangement, independent of any restriction as regards the point from which that view might be supposed to be taken. We imagined ourselves, for the moment, stationed at a distance that might be sufficient to afford a view of the whole, as of a scene spread before us. This simplification gave us a clear idea of the extent and general dimensions of the subject; but now that we are to inquire into the circumstances of each separate body in detail, we must consider our view as taken from the earth, the station from which our observations are naturally made.

It is, in some degree, necessary to have these two different points of view in our recollection: the one, because *we know* the sun to be the true centre of the system; the other, in which we are *compelled to view* the appearances of the heavens and planetary motions, as if the earth were really in the centre, because it *seems* so to us. The one, therefore, respects the *real* situations and motions; the other respects their *imaginary* or apparent situations. The real view is sometimes called HELIOCENTRIC, a term compounded of two Greek words, signifying, the sun in the centre: the apparent view is termed GEOCENTRIC, signifying, the earth in the centre.

SCENE NO. VII.—THE SUN'S DISC.

It has been already stated that the sun is the central body about which the system and its planets revolve; that its diameter is somewhat more than 886,000 miles; and that it has a motion of rotation on its own axis. The period of this rotation is, correctly, 25 days, 14 hours, and 8 minutes.

The scene exhibits the sun's disc as it appears when viewed through a telescope of moderate magnifying power.

When we look at the sun with such a telescope, furnished with a coloured glass to intercept a portion of its light, we occasionally find a number of dark spots, of various forms and magnitudes, similar in their appearance to those here shewn. Such spots have frequently been sufficiently large to be seen by the unassisted eye; yet their existence was not discovered till after the invention of the telescope. They were first observed by Fabricius, a German astronomer, in 1610; and in 1611, by Galileo, the inventor of the telescope; and by Scheiner, a German mathematician. To which of these eminent men the honour of this discovery belongs is now unimportant, but the discovery itself was of great value to the science of astronomy; inasmuch as the frequent observation of these spots has enabled us to determine the fact of the sun's rotation on his axis, and the period of that rotation.

The spots of the sun have been assiduously observed by the astronomers of modern times, and many interesting facts have been elicited respecting them. They are of various magnitude and form: most of them have a very dark nucleus, or centre, surrounded by a fainter shade, and they frequently undergo rapid changes, even while under observation.

Besides these changes, which are owing to some cause with which we are yet unacquainted, they present variations of an optical nature, from their changes of position on the face of the sun. When a spot is seen near the middle of the sun, its breadth is then at the greatest; but it diminishes gradually as it moves towards the edge of the disc. From these appearances it is obvious that the spots are actually upon the surface of the sun: and as their motion across the sun is constantly in the same direction, from west to east, it is evident that these variations are produced by the rotation of the sun about his axis. In the scene, the forms of the spots are given in the varieties we generally observe, without any intention of making a portrait of the sun at any particular time. The spots appear narrower as they approach the edge; the narrow lines, near the upper part of the figure, shew their appearance just before they pass off the sun.

About the year 1779, the sun's spots were examined by Dr. Herschel with his powerful telescopes; an accurate and laborious examination was continued during many years, and has disclosed highly curious phenomena, which tend to explain the actual nature and construction of the sun. Dr. Herschel considered the surface of the sun to be composed of luminous clouds floating about, and entirely surrounding it; and the dark nucleus, or centre of the spots, to be the opaque body of the sun appearing through casual openings in his luminous covering.

The Planet Mercury.

Mercury is, as before stated, the planet nearest to the sun; and it can, therefore, never be seen by us far removed from that luminary, or at a greater apparent distance than fifty-six times the apparent breadth of the sun from it. The planet is seen alternately before the rising and after the setting of the sun: it appears a little before the sun rises, and again, in another part of his orbit, a little after sunset. It is never to be seen longer than one hour and fifty minutes before the sun rises, nor longer than one hour and fifty minutes after the sun sets. This proximity to the sun naturally renders the light of the planet much less effective than it would be if seen at a greater distance from him; it is for this reason that Mercury is seldom seen. When the air is unusually clear and serene, with a good telescope he is visible at the times stated. His apparent diameter is about 175th part of the apparent diameter of the sun.

The telescopic view of Mercury is that of a planet having phases (a term derived from the Greek, signifying *appearances*), or assuming that alternate increase and decrease of form and of light under which we see the moon, with this difference, that Mercury never appears quite full to us, because his enlightened side is never turned directly towards us, except when he is so near the sun as to be invisible to us.

As in the case of the moon, the crescent, or enlightened side of Mercury, is always turned towards the sun. This circumstance, with the increase and decrease of his light, shews us that the planet does not shine by light of his own; and the fact of his enlightened portion being always towards the sun, proves to us that his light is derived from that source.

It was by the assistance of the powerful telescopes of modern times alone, that astronomical observers discovered spots on the surface of this planet; and thence determined that it has a motion of rotation on its own axis in twenty-four hours and five minutes.

Its distance from the sun is 37 millions of miles; its diameter 3,224 miles; and the time in which it performs a revolution about the sun very nearly eighty-eight days.

The orbit of Mercury being within that of the earth, the planet is sometimes in a position directly between the earth and the sun, and it then appears as a *dark spot* passing over the sun's disc. This phenomenon is called a transit of the planet—(such transits can take place only in the case of planets whose orbits are within that of the earth, as Mercury and Venus); the appearance of the planet during a transit, being that of a perfectly round and black spot, affords us further proof that it is of itself an opaque body.

Mercury, although presenting to the naked eye the appearance only of a small star, emits a remarkably brilliant white light of dazzling splendour, by which, at the proper times, he may be readily recognised.

Scene No. VIII.—The Planet Venus.

The planet Venus is the most brilliant and beautiful star in the heavens, and is emphatically called the morning and evening star, because she is never seen in the opposite quarter of the heavens to the sun, but always seems to attend him in the evening, in the west, and to precede his appearance in the morning, in the east. Venus is the second planet from the sun, and her orbit, being, like that of Mercury, also within that of the earth, she is seen alternately before the rising, and after the setting of the sun; at such times she shines with great brilliancy, but she is often to be distinctly seen at other periods of the day, even by the naked eye.

Venus appears to us, like Mercury, under all the phenomena of an increase and decrease of figure and of light common to our moon. This planet, like Mercury, is also sometimes seen to transit, or pass, over the sun's disc, in the form of a round black spot, proving, as in the case of Mercury, both that the planet is an opaque body, and that she revolves about the sun at a less distance than the earth, as well as that she is of a very small diameter, as compared to the sun. A few days after passing over the disc of the sun, Venus is seen, in the morning, *west of the sun*, in the form of a thin crescent, like our new moon, and having her convex side turned *towards the sun*, moving gradually westward with a *retarded motion;* in ten weeks after this she has travelled so far westward towards the extent of her orbit, that she seems stationary, because moving at this time nearly in the same direction in which we look at her, we do not perceive her progressive motion; soon after this, however, she appears to move eastward with a motion *gradually accelerated*, for she is now moving round the farthest side of her orbit from us; she continues this course, and passes *behind the sun* in about nine months and a half after having been seen on his disc. Some time after this, she is seen in the evening, east of the sun, of a round figure, but very small. Continuing to move eastward, she increases in diameter, gradually losing the appearance of roundness, until she arrives at the *eastern extremity* of her orbit, or distance from the sun, when she is of semicircular form, and again seems to be stationary. She afterwards moves westward, appearing to increase in diameter, because she is now moving in that half of her orbit nearest to the earth, which she is, therefore, approaching; she is now, however, becoming of crescent form, like a waning moon; and at last, after a period of 584 days, appears to come again to the sun.

When a planet is so nearly on a line with the earth and the sun, as to pass between them, it is said to be in its *inferior conjunction;* when behind the sun, it is said to be in its *superior conjunction.* When at its greatest apparent distance from the sun, east or west, a planet is said to be at its greatest *elongation* in that direction.

The scene before us represents the telescopic appearance of Venus, as she is seen in two distinct points of her orbit. When she is at either of her points of greatest elongation, or stationary, as I have described, she has the semicircular figure, the convex side being turned towards the sun; when she is in, or near to, her *inferior conjunction,* she appears in the crescent form, as in the scene, having its convexity always towards the sun.

When Venus is in that part of her orbit which brings her to her nearest point of approach to the earth, she appears to us in the crescent form; her apparent diameter is, at that time, more than four times larger than when she was at her greatest distance from us, and her light is, therefore, by so much, the more brilliant, although her figure is at these times of more slender form. In a telescopic view of the planet, she appears much brighter on the outer or convex border, than on the inner, or straight boundary of light, as is shewn in both the figures of the scene. Spots of the character shewn in the larger figure are seen, and mountains of great height are determined to exist on her surface. In her crescent shape, the lower horn, or corner of her disc, was observed by Schroeter, an eminent German astronomer, to be considerably blunted, and having in its immediate vicinity, in the dark, or unenlightened portion of the planet, a detached bright spot; this, after careful observation, was determined to be a mountain of great elevation. By a continued examination of this spot, this astronomer found the same appearance recur uniformly at regular periods, and the rotation of Venus on her own axis was thence concluded to be performed in twenty-three hours and nearly twenty-one minutes. The mountain observed is supposed, by Schroeter, to be upwards of twenty-two miles in height. The diameter of Venus is 8,648 miles, and the time in which she performs a revolution about the sun, is 224 days and 17 hours.

Venus is a morning star, or appears to us west of the sun for about 290 days, and then becomes an evening star, or is, to us, east of the sun for nearly the same length of time, although her entire revolution round the sun is actually completed in 224 days and 17 hours. A short and simple explanation will reconcile this seeming contradiction; and the reason of what, at first sight, appears a startling difficulty, will become obvious.

It was just now said, in describing the motion of Venus round the sun, that, from the time of her quitting its disc, to that of her conjunction with it again, a period of 584 days elapsed. In this calculation the motion of Venus round the sun was not considered *alone;* the motion of the earth is concerned in it, in a very important manner; for *while Venus is travelling on in her own orbit, at the rate of* 80,000 *miles an hour, the earth is also travelling in the same direction, in hers, at the rate of* 68,000 *miles an hour;* and being at a greater distance, and moving at a slower rate than Venus, it will follow that neither the one nor the other is in the same part of its orbit, at the happening of one conjunction, that each was in at the former. Thus, before a conjunction could happen again, Venus will have gone about twice and a half round her orbit, and the earth about once and a half round hers; for the period between the conjunctions is 584 days. This is termed her *synodic revolution:* the word synodic is compounded of two Greek words, signifying, *on the way together.*

The earth, traveling at the same time, and in the same direction with Venus, makes Venus seem to move more slowly than she really does,—her apparent motion to be slower than her real motion. During one half of this, her synodic revolution, she appears to us to the west, the other half, to the east of the sun.

The distance of the planet Venus from the sun is 68,685,000 miles.

Scene No. IX.—The Planet Mars.

Mars is the first, or nearest to the earth, of the superior planets, or those whose orbits are beyond that of the earth. This planet is remarkable for the redness of its light, and the variety of spots which appear upon its surface, when examined with the telescope; the colour of its light is supposed to be occasioned by an atmosphere of great density and extent, and the variety and singular configuration of its spots, to arise from collections of thick clouds or vapours.

To the naked eye Mars presents nothing remarkable in his appearance, except the red colour of his light; but, seen through the telescope, his disc appears alternately circular and elliptical, varying with its changes of position with regard to the earth. The phases presented by Mars differ from those shewn by Venus, in their never being crescent-formed; this planet not being between the earth and sun, as Venus is, we do not see its light in all the same varieties of form. Its general appearance, to us, is in the form called *gibbous*. This term is used by astronomers to denote the appearance of the light of the moon, or any of the planets, whenever *more than half* the illuminated part of its disc is seen, and *less than the whole;* the edge of its light, next the unilluminated portion of the disc, is then irregular, and, as it were, knotty; from the Latin *gibbus*, signifying *a cluster*. The ruggedness of the edge is only to be seen by the help of a powerful telescope, which discovers that the disc, when it does not appear circular, takes distinctly an elliptical form. The scene exhibits two figures of Mars, such as may be seen by means of the telescope, with different configurations of his spots, or clouds. His polar regions are subject to great changes as to intensity of light; sometimes they appear bright, at other times dull. The portions about the southern, or lower portion of the disc, are the most brilliant; and this brilliancy, after entirely disappearing, frequently returns with its original brightness. These changes of appearance, at the poles of Mars, are attributed to the presence of large masses of ice, which are collected there, and occasionally dispersed by the periodical exposure of those regions to the sun.

The diameter of Mars is 4,431 miles, and his distance from the sun 145 millions of miles. The distance of the earth from the sun being only 95 millions of miles, it follows that Mars moves about the sun in an orbit, 50 millions of miles on the outer side, as it may be termed, of our orbit, or more distant from the sun; and the earth is, therefore, periodically, at very unequal distances from Mars; as, for instance, in one part of her orbit, the earth is but 50 millions of miles distant from Mars, while, at the opposite point of her orbit, she is 240 millions of miles from him. The difference in his apparent size is nearly as three to one. Mars performs a revolution about the sun in 1 year, 321 days, 17½ hours, of our time. The telescopic spots on Mars have enabled us to ascertain his rotation on his axis to be made in twenty-four hours and thirty-nine minutes. This rotation of the planet being accurately established, it was expected that, in conformity with the laws of gravity, it should have a spheroidal form, of similar character to that of the earth. The gibbous appearance of Mars occasioned considerable difficulty in taking accurate measures of his equatorial and polar diameters. Dr. Herschel, however, succeeded in the attempt, and determined the figure of Mars to be an oblate spheroid, whose equatorial diameter is, to the polar diameter, nearly in the proportion that sixteen bears to fifteen. It will, doubtless, be recollected, that the oblate spheroid is the figure we assigned to the earth, when we considered her form and dimensions.

The Planet Vesta.

The planets next in succession to Mars, as respects distance from the sun, are the small ones called Vesta, Juno, Ceres, and Pallas: these four planets were by Herschel termed *asteroids* (from two Greek words, signifying—in the *forms of stars*, or having the *appearance of stars*); they were discovered in succession, within a few years of each other, at the beginning of the present century.

The planet Vesta was discovered on the 29th of March, 1807, by Dr. Olbers, an eminent astronomer, at Bremen, in Lower Saxony. Vesta has the appearance of a very small star, and may be seen in a clear evening by the naked eye. Her light is very pure, white, and intense. Her distance from the sun is computed to be 225 millions of miles; her diameter is unknown: the time in which she performs a revolution about the sun is 3 years and 274 days.

The Planet Juno.

This planet, the next beyond Vesta, was discovered by Mr. Harding, at his observatory near Bremen, on the 1st of September, 1804. Her distance from the sun is computed to be 254 millions of miles; her diameter 1,425 miles; her revolution about the sun is performed in 4 years and 128 days. Juno appears of a reddish colour, and is always of a uniform brightness. The diurnal rotation of this planet is unknown.

The Planet Ceres.

Ceres, the next planet beyond Juno, was discovered at Palermo in Sicily, on the 1st of January, 1801, by Piazzi. Her diameter, as computed by

Herschel, is about 170 miles; her distance from the sun is 263 millions of miles; and her motion of revolution about the sun is performed in about 4 years and 200 days.

The Planet Pallas.

The planet Pallas, the next beyond Ceres, was discovered on the 28th of March, 1802, by Dr. Olbers, of Bremen, the discoverer of the planet Vesta. The diameter of Pallas has not been determined with accuracy; but with a good telescope, the disc, or surface, may be readily observed. Her distance from the sun, like that of the planet Ceres, is about 263 millions of miles; and she performs her revolution about it nearly in the same time—*viz.* 4 years and 200 days.

Scene No. X.—The Planet Jupiter.

Jupiter is the ninth planet in order of distance from the sun. His distance from the sun is 494,285,000 miles; his diameter is 89,069 miles, somewhat more than eleven times the diameter of our earth. Jupiter performs a revolution about the sun in 11 years and 315 days. He has a motion of rotation on his own axis in nine hours and fifty-six minutes; which is, therefore, the length of his day. Owing to this rapid motion on his axis, Jupiter is more flattened at his poles than some of the other planets. His form, like that of the earth and Mars, is an oblate spheroid; the equatorial diameter being to the polar diameter in the proportion of fourteen to thirteen.

When we examine Jupiter through a good telescope, we see several belts, or bands, extending across his disc, in lines which are parallel to his equator. These bands, or belts, as they are termed, are variable in number, distance, and position. Sometimes four or five belts are seen; frequently as many as eight. He has been seen, having the disc entirely covered with very small and slightly curved lines; but large parallel belts, from three to four in number, are most common, and, in favourable weather, may be observed distinctly with a good achromatic telescope, with a magnifying power of forty times. The scene exhibits the disc covered with belts of this description, as they are shewn through larger telescopes. They are sometimes interrupted, or broken in their length, as in the lower part of the figure in the scene: at other times they seem to increase and diminish alternately, to run into each other, and sometimes to separate into others of a smaller size. This changeable character is shewn in the middle part of the figure. Spots of a darker colour than the belts are observed, of form and general appearance as in the figure, which are the shadows of his satellites, thrown on the body of the planet.

Different opinions have been entertained by astronomers respecting the cause of the belts and spots of Jupiter. By some they have been considered as clouds; by others, as openings in a surrounding atmosphere of the planet;

while others have imagined them to be of a more permanent nature, and the exhibition of great physical revolutions, which are perpetually agitating and changing the surface of the planet. The latest observations of astronomers have, however, induced them to conclude, that the brighter parts of Jupiter's disc are the clouds and vapours of his atmosphere, while the darker parts are the actual body of the planet.

It has already been stated that Jupiter is attended by four satellites, or secondary planets. The shadows of some of these are occasionally visible upon his surface: we hence conclude that their light is received from the sun; that they operate to illuminate the planet; and that, to Jupiter, his satellites exhibit all those variations of figure and of light we see in our satellite, the moon: to us they always appear circular.

The four moons of Jupiter must afford very considerable light to the planet; for that nearest to his surface appears to him of four times the apparent size of our moon to us; the second appears to him about the size of our moon; the third somewhat smaller; and the fourth about one-third of that size. These moons revolve about the planet in a direction from west to east; and, from the observations of Herschel, it is believed that they have a motion of rotation on their own axes, also, in the same direction, and performed in the same time as that in which they respectively perform their revolutions about the planet; so that each satellite constantly turns the same side towards the planet, as is the case with our moon as regards the earth.

With the aid of the telescope the satellites of Jupiter are frequently seen to pass over his disc, and also to disappear, by passing, as they must necessarily do, in a portion of their orbit, through the shadow which Jupiter throws behind him from the sun. The periods in which the satellites circulate about the planet being short, these phenomena occur very frequently. When a satellite appears to enter the shadow of the planet, or to disappear, the disappearance is termed the *immersion* of that satellite—it is immersed in the shadow; when, after passing through the shadow, it re-appears, the re-appearance is termed its *emersion*—it emerges from the shadow. With a telescope, even of moderate power, the planet, with its satellites, may be seen together, as shewn in the lower part of the scene. The satellites are then observed in continual motion, as it were; they are sometimes arranged in a line, some of them on one side of the planet, some on the other; at other times they are all seen to the right or left of the planet: they will then change their relative positions, and, occasionally, are visibly immersed in the shadow of the planet, disappear, and, in due time, emerge from it.

The distances of these satellites from the planet, as well as their rates of motion, being materially different, the time occupied in their respective eclipses also differs considerably. The period of revolution of each satellite about the planet increases with the distance from it; the time occupied by their respective eclipses increases in the same order.

The first, or nearest satellite, revolves about the planet in	$1\frac{3}{4}$ day;
Its eclipse lasts about	2 hours.
The second satellite revolves about the planet . .	$3\frac{1}{2}$ days;
Its eclipse lasts	3 hours.
The third satellite revolves in	7 days and 4 hours;
Its eclipse occupies	$3\frac{1}{2}$ hours.
The fourth satellite revolves in	17 days;
Its eclipse occupies nearly	5 hours.

The planet Jupiter, with his satellites, is an object of great curiosity and interest on several accounts. The observation of the eclipses just described, has furnished us with the means of correctly determining what is termed the longitude. They afford us a method of estimating the distances of Jupiter from the sun; and it was by the exhibition of this phenomenon that astronomers made the curious and important discovery, that the sun's light has a progressive motion; that it is not spread or transmitted through space *instantaneously*, but at a *rate of motion* which is strictly measurable: this was effected by means of the eclipses of Jupiter's satellites.

This planet and its satellites, taken collectively, present a perfect representation in miniature of the entire solar system. The laws which govern the movements of our planetary system, in its revolution about the sun, are perfectly exhibited in the circulation of these satellites about their primary planet. Their orbits are slightly elliptical, like those of all the planets, and their revolutions are made in the same direction as those of the planets, *viz.* from west to east.

Scene No. XI.—The Planet Saturn.

The planet Saturn is the tenth planet from the sun; his distance from it has been already stated to be 907 millions of miles. The most careful measurements of his diameter make it 79,042 miles. He performs a revolution about the sun in 29 years, 174 days, 1 hour; moving at the rate of more than 22,000 miles per hour. By the motion of the spots observed on his surface, and by his distinct stripes, or belts, similar to those of Jupiter, it is ascertained that he has a motion of rotation on his own axis in ten hours, sixteen minutes. This rapid motion, together with another cause that will presently be noticed, has produced a remarkable depression of his figure at the poles. When examined with a powerful telescope, the equatorial diameter of Saturn is found to be in proportion to his polar diameter as very nearly twelve to eleven.

Saturn is attended by seven satellites, which revolve about him in different periods, and in a direction from west to east. But Saturn is more particularly distinguished from the other planets by the extraordinary appendage of his vast luminous ring.

Although, through a common telescope, Saturn seems to be surrounded but by one broad ring, a telescope of high magnifying power shews that there are at least two rings, lying in the same plane, and forming two distinct concentric circles about the planet, the ring which is nearest to him being much broader than the outer one, with a well defined space between them. The innermost edge of the nearest ring is nearly 4,000 miles from the body of Saturn, leaving a visible space, through which some of the fixed stars have been seen, between the planet and the ring. The breadth of the two rings together, is about 30,000 miles. Herschel is of opinion that these rings are solid, since they not only reflect the sun's light, but also throw a strong shadow on those parts of the planet from which they intercept it.

The two rings rotate together about the planet, but are about thirteen minutes longer in performing their rotation than Saturn is in making his revolution on his own axis. The surfaces of the rings are permanently at right angles with the axis of the planet, which is considerably inclined to its orbit.

The remarkable depression at the poles of Saturn is, in part, attributed to his quick revolution upon his axis; in part, also, to the attraction existing between his body and his ring, which must constantly lessen the gravity of his equatorial parts.

The upper figure of the scene represents a telescopic view of the planet, with its rings and satellites. The small figure in the lower part of the scene, shews the planet and satellites at their general apparent distances from its body.

Before the invention of the telescope, the planet Saturn held no particular rank in the heavens, beyond that distinction which the slowness, yet regularity of its motion, and its steady brilliancy rendered remarkable. Its singularity of appearance was first observed by Galileo in 1610: his discoveries in Jupiter and Saturn were the first fruits of his invention of the telescope. He described this planet as consisting of three globes—one large, with a smaller one on each side. He veiled his discovery in a Latin sentence, which he transposed, that his observation might remain secret, and yet afford him, at some future time, the means of establishing his claim to the honour of the discovery. Huygens, also a learned astronomer, and contemporary with Galileo, actively continued the observations, and completed the discovery, by a full explanation of the phenomena of the ring, in substance precisely as it is understood by astronomers of the present day. The explanation was briefly thus: that the planet, in its course round the sun, holding its ring, as it were, always in the same position, as regards its axis of rotation, and being always seen from the earth within a limited obliquity, necessarily assumed a limited variety of oval forms—gradually contracting from a certain ellipticity to an almost imperceptible line, and again expanding till it resumed its maximum of ellipticity.

The actual dimensions of the planet, and its two rings, from the observations and measurements of Herschel, are as follow :—

The diameter of the body of the planet itself	78,730 miles.
The distance between the body of the planet and the inner edge of the first, or nearest ring	33,807
The width of the nearest ring	20,000
The space between the two rings	2,839
The width of the outer ring	7,200
The entire width of the double ring	30,039
The entire diameter of the outer ring, or the extreme dimension of the planet and its ring	206,422

A particular explanation of the phases, or changing appearances of Saturn, form the subject of a separate scene.

Scene No. XII.—The Planet Herschel, or Uranus.

The planet Herschel, or Uranus, is the eleventh planet, in order of distance, from the sun, and is the most remote of the solar system, as far as our limited powers of observation have yet informed us. It is situated as far beyond the orbit of Saturn, as Saturn is from the sun. Its distance from the sun is more than 1,800 millions of miles; accurately, 1,812,600,000 miles. Its diameter is 35,112 miles. It performs a revolution about the sun in 84 years, 8 days, and 18 hours, moving in its orbit at the rate of nearly 15,500 miles per hour. Astronomers have not discovered any indication of a rotatory motion on its own axis; but, reasoning by analogy, it is concluded that it revolves with a rapidity equal to that of the planets Jupiter or Saturn.

This planet was discovered by Herschel, in 1781. It had been long known to astronomers simply as a fixed star; its motion and phenomena, as a planet of our system, or the existence of its satellites, had not been observed or imagined till they were announced by Herschel.

Astronomers have observed that, when the planets approach one another, each exerts on the other that power which we term *gravity*, or attraction: this power being always in proportion to their quantity of matter and distance from each other, causing, on their nearest approach, what, in regard to the immensity of their orbits, may be termed *slight deviations* from their regular course. Now, some remarkable disturbances and deviations of this nature, in the motions of Jupiter and Saturn, were observed by astronomers *before the discovery of the planet Herschel*, which they could only account for by supposing them to be caused by *some planet still more distant from the sun than Saturn.* This is an interesting circumstance, inasmuch as it shews us the extreme accuracy with which astronomers observe the motions of the planets. Many years after this opinion first prevailed, it was completely verified by

Herschel, in his discovery of this planet, which, in honour of the reigning monarch, he named the Georgium Sidus ; by the astronomers of most foreign countries it is called Herschel, after its discoverer ; by the astronomers of Prussia, and some others, it is called Uranus : by this name it is now most generally known.

Uranus appears to us about the size of a star of the smallest visible magnitude, having a faint blue light ; it may, occasionally, be discovered without the help of a telescope, in clear weather, and in the absence of the moon ; but the disc appears distinct and well defined, when observed through a telescope magnifying two or three hundred times.

The scene represents, in the upper figure, a telescopic view of the planet, as seen with a great magnifying power. The small lower figures represent our earth and moon, of the proportion their diameters bear to the planet Uranus, which, perhaps, makes a more satisfactory impression on the mind, of the dimensions of this planet ; and, with reference to its diminutive appearance in the heavens, gives a clearer idea of its vast distance than a statement in figures.

Uranus is accompanied by six satellites, all of which move round him nearly at *right angles to the plane of his orbit ;* whereas, the orbits of the satellites of Jupiter and Saturn are nearly in the same plane with the orbits of the planets themselves. The most remarkable phenomenon, however, exhibited by the satellites of Uranus, is, that their motion is *retrograde,* or directly the reverse of that of the satellites of the other planets, and of the planets themselves, which we have shewn to be in a direction from west to east ; whereas, the satellites of Uranus move round him in a direction from *east to west.*

The first, or nearest satellite to the planet, is distant from it	230,330 miles.
The second	298,830
The third	348,390
The fourth	399,590
The fifth	746,240
The sixth	1,597,700

	Days.	Hours.	Min.
The nearest satellite revolves about the planet in	5	21	25
The second	8	17	
The third	10	23	4
The fourth	13	11	5
The fifth	38	2	
The sixth	107	16	40

The satellites of Uranus were not discovered with the planet itself ; the second and fourth were first seen six years after the discovery of the planet, *viz.* in 1787. The other four were discovered in 1790 and 1794.

Scene No. XIII.—The Moon at the Full.

We will now examine our moon, which may be justly designated the companion of the earth, in its annual course round the sun. Next to the sun itself, the moon is, to us, the most conspicuous of the heavenly bodies; the changes she undergoes in her appearance are more remarkable and more obvious than those of any other objects in the planetary system, and her apparent motions are more rapid. Hence, the motions and changes of the moon engaged the attention of astronomers before much was known to them of those of the sun; and hence it was that the earlier inhabitants of the earth reckoned their time by the apparent motion of the moon, calculating by a lunar, not a solar year.

Astronomers concur in determining the distance of the moon from the earth to be 237,360 miles, about 1-400th part of the distance of the earth from the sun. The moon's diameter is computed to be 2,160 miles. That the moon is a body of a spherical figure we have very frequent opportunity of seeing; as well as that she is subject to constant, regularly repeated variations of light and shadow. The most remarkable of the phenomena exhibited by the moon, are these continual changes of figure; sometimes she appears perfectly circular, at other times only half illuminated, or even resembling a thin thread of light, of a semicircular form, changing through all the gradations of figure between those extremes: and as these changes of appearance are always found to be alike at the same elongation, or apparent distance from the sun, they prove that the moon receives her light from the sun; for as the moon is enlightened on that side only which faces the sun, a greater or less quantity of that enlightened part will be visible to us, according as it is turned towards us or from us, and her figure will, consequently, appear to vary through the whole of her revolution.

It is a circumstance of familiar observation, that, during a few days of each month, or lunation, we do not see the moon; even in the clearest weather, we have, at those times, no moon-lighted nights: as it is said, *there is no moon*. The explanation of this case is, simply, that the moon is at that time in that part of her orbit which lies between the earth and the sun, and is, therefore, invisible to us, because her enlightened side is then turned wholly towards the sun, her unenlightened and invisible side towards the earth; she is in the position termed her *conjunction:* a term already explained when speaking of the planet Venus. When this interval has passed, we first see the thin bright crescent which we term the *new moon*, a little to the east of the sun, after he has set in the west, and a little above the horizon, shewing the small visible portion of the illuminated part of her disc turned towards the sun. A few evenings after this, the moon appears in the south, when the sun is in the west, and one-half the enlightened part of her disc is then visible; at the end of a few days more she appears in the east, when the sun is in the west, and with the round illuminated face which we call the *full moon*. She is then in, what the astronomer terms, *opposition;* the earth is between the sun and the moon. After the full, her enlightened side, gradually, night by night, appears less to us, until her next conjunction; when she is again between the earth and the sun: she then disappears for a short interval, as before; and in a few days she again appears, a little after sunset, to the east of the sun, in her fine crescent form; and we say it is again *new moon*.

The variations of light exhibited by the moon may be represented very correctly, by placing a lamp on a table to represent the sun; a small terrestrial globe, at a distance of three or four feet from it, to represent the earth; and then carrying a smaller white ball round it, to represent the moon revolving about the earth.

In this simple experiment, the observer's eye is supposed to be just above the globe representing the earth, and looking towards the ball representing the moon. When the latter is between the sun and the earth, or *in conjunction*, its dark side will be towards the earth. Having advanced one-eighth part of the circle round the earth, the moon will appear horned; she is then said to be in her *first octant*. When advanced one-fourth of the circle, one-half of her illuminated side is turned towards the earth; the moon, in that position, is said to be in her *first quarter*. When advanced three-eighths of the circle, she appears gibbous, and is then said to be in her *second octant*. When half the circle is made, the earth is then between the sun and moon, and her whole enlightened side is turned towards the earth; in this position she is *in opposition*—she is in her *second quarter*, and appears, as it is termed, the *full moon*. Advanced five-eighths of the circle, she appears again gibbous, and is in her *third octant*. When three-fourths of the circle are made, one-half of her illuminated side is again turned towards the earth; she is then in her *third quarter*. When seven-eighths of the circle are completed, she appears again horned, and is in her *fourth octant*. Advancing one-eighth more, she completes the circle; and, having made her revolution about the earth, is again between the earth and sun, or *in conjunction*. It is then *new moon* again.

The real time occupied by the moon in performing a revolution about the earth is accurately 27 days, 7 hours, 43 min., 14 sec.; but the *apparent* time of her revolution, or the period occupied by the moon in going through the succession of phases just described, is 29 days, 12 hours, 44 min., 3 sec. To each of these periods we give the name of *month*: the former is called the *periodical month*, comprising the period of the moon's course round the earth; the latter the *synodical month*, comprising the period at the close of which the sun and the moon are *on the way together*. The reason of the difference is this:—The moon would actually make a complete revolution about the earth in the periodical month, if the earth remained stationary; but while the moon travels in her orbit round the earth in a direction from west to east, the earth itself is, at the same time, travelling in her own orbit round the sun, and in the same direction, from west to east. The result is that, when the moon has spent 27 days, 7 hours, 43 min., and 14 sec., moving forward in her orbit (which would have been sufficient to complete her revolution had the earth been stationary), the earth has advanced at the same time in her own orbit, leaving the moon, as it may be said, two days and a little more than five hours *behind*, before she can complete her revolution about *the earth in motion;* she must therefore travel on, a certain time longer, till, by her greater speed, she accomplishes it. This time is 2 days, 5 hours, and 51 seconds; thus making her complete *synodical* revolution 29 days, 12 hours, 44 min., 3 sec.

The moon has a motion of rotation on her own axis, in the same time which she takes to make a revolution about the earth. The moon's motion on her own axis is perfectly uniform; this has been determined by the important and curious fact, that she always presents *the same face* to the earth, at least with very little variation. But as her motion in her orbit is not equable, but alternately accelerated and retarded, while that on her axis is uniform, small portions of her disc on the eastern and western sides alternately appear and disappear. This produces an apparent vibration of the moon from side to side, which is termed her *libration.*

The moon has also another apparent vibratory motion, by which small portions of her disc on the northern and southern edges are alternately shewn; this, also, is termed a libration. The first of these is termed the moon's *libration in longitude;* the other her *libration in latitude.*

The moon, being the nearest celestial body to the earth, is naturally a very interesting object for telescopic observation.

The scene represents the face of the moon, as she appears through a powerful telescope, at the full, or, what is termed, in opposition.

The surface of the moon, when viewed in this manner, presents a great diversity of irregular forms, and great differences of illumination; but the principal masses of light and shade are visible to the naked eye. Some spots resemble, in a striking manner, the appearance of mountains and valleys, and the effect of volcanic disturbances; and some observers have even imagined that they could distinguish volcanoes in a state of active combustion. The height of the lunar mountains was, formerly, supposed to exceed very greatly that of the loftiest elevations on the earth; but the laborious researches of Herschel, Schroeter, and other modern observers, have determined that none of the lunar mountains much exceed five miles in height.

Many of the older and celebrated astronomers have published maps of the face of the moon; the most esteemed are those of Hevelius and Cassini. Of the modern delineations, the large views of Russel, published about forty years since; of subsequent date, the elaborate drawings of Schroeter; and, still more recently, the brilliant and useful Selenographia of the author of this lecture, are the accepted standard works.

The earliest applications of the telescope were to a series of observations on the moon's surface. The extremely different appearances which the same parts assume under the view of the telescope, even at one observation, are highly interesting; its rugged and diversified surface, or its elevations and depressions, are, under telescopic examination, satisfactorily understood from these changes of appearance. We find those spots of the moon, which are considered to be mountains or valleys, exhibit appearances which distinctly prove them to be so. We find that, in all situations of the moon, except that of her opposition, the more *elevated* parts constantly produce shadows in a direction *opposite* to that of the sun, and that the *cavities*, or depressions, are always dark on the side nearest the sun, and illuminated on the opposite one; and that the shadows of the convex or elevated portions become progressively shorter, as the sun's light becomes more direct on the surface, while the lower tints of the retiring parts, or cavities, become less dark, by reason of the same change of direction of the sun's light. We find that, as any given portion of the surface is in progress of removal from the direct illumination of the sun, the shadows of its projections, or elevated parts, invariably increase in length; and that, as the light becomes more oblique, the colour of the cavities becomes still deeper. These appearances, being perfectly consistent with what we observe in the case of all surfaces diversified by elevations and hollows, satisfy us that such is the actual condition of the moon's surface.

These changes, which are continually going on, may be seen in any stage of a lunation, but are more striking at about seven days before and after the full moon. With a telescope of high magnifying power, and under favourable circumstances for the observation, the changes of forms and colour go on with a *visible* rate of progress. If the observer commence an examination of this kind with a general view of the entire disc—for which purpose he must use a telescope of low magnifying power, as from twenty-five to forty times—the larger dark spots, which are visible to the naked eye, resolve themselves into apparent cavities, distinct spots of minor character, and ramifications of an infinite diversity of colour and figure. In addition to these he finds other, and, if the subject be entirely new to him, most unexpected and delightful appearances. He perceives extensive valleys; long ridges of mountains, of great elevation; single mountains, occasionally rising to a still greater apparent height; with vast hollows, or excavations in the plains, of the estimated depth of nearly four miles, and generally of a singular uniformity of form and character. It will be observed that these appearances are not constant, but change their general character, form, and intensity of colour, with the changes of the moon's place in her orbit. When she approaches to her opposition with the sun, or the full, the mountainous elevations, and the depressions of her surface, gradually incline to a character of more uniformity, while the entire disc assumes a new and equally beautiful appearance. Points of sparkling light, and larger spots of different degrees of brilliancy, slowly take the place of the rugged and more distinctly marked tracts before observed; and permanent irradiations, of various tints and brightness, traverse the whole surface, and present a new picture. The scene before us is a representation, on a small scale, of this telescopic general view.

Astronomers, by common consent, distinguish the remarkable spots, mountains, and cavities of the moon's surface, by the names of celebrated men who, in the early stages of astronomical inquiry, laboured for its advancement; or by appellations which seem, in a general way, to suit their localities, or their supposed peculiarities.

The moon is not surrounded, like the earth, by vapours or clouds; for, whenever she is visible to us, she appears with the same serene, clear, and calm aspect. It is a generally received opinion, that there is no water upon the moon; and hence we are entitled to infer, that none of those atmospherical phenomena which arise from the existence of water on our own planet will take place in the moon.

The mountainous scenery of the moon bears a stronger resemblance to the terrific ruggedness of the Alpine regions of the earth than to the quieter inequalities of less elevated countries. Huge masses of rock, with peaked summits, rise at once from the plains to an immense height in the air; crags project from their flanks and faces, which seem, in their position, to contradict the laws of gravity, and threaten devastation to the valleys below, by their fall. About the bases of these frightful rocks there seem strewed the unconnected fragments of ancient disruptions; and, from the character of the overhanging cliffs, we expect to witness some similar process of destructive separation. In some places lines of mountains rise abruptly, with a precipitous front, from a continuous level, and are, at times, above four miles in perpendicular height.

Our next scene may be considered a descriptive key to the principal spots of the moon's surface, as shewn pictorially in the present scene.

Scene No. XIV.—The Nomenclature of the Lunar Spots.

This scene is an auxiliary sketch to the last, in which we can more conveniently read the references to the following list of the leading features of the general view:—

The spot A, near the lower part of the disc, is named	*Atlas.*
B, a little to the left, near the edge of the disc . .	*Schickardus.*
C, a little above A	*Pitatus.*
D, next above C	*Bullialdus.*
E, lying to the left of D	*Gassendus.*
G, a large spot above E, and near the edge of the disc	*Grimaldus.*
H, very near to G, nearer the edge of the disc . .	*Hevelius.*
I, above H, and but a little removed from the edge of the disc	*Aristarchus.*
K, immediately below I	*Kepler.*
L, to the right, and near to K	*Copernicus.*

M, near to L, on the right	*The Appennine Mountains.*
N, directly above M	*Archimedes.*
P, a considerable space to the right of N	*Possidonius.*
Q, a little below P, and near the edge of the disc	*Cleomedes.*
R, a large spot near the centre of the disc . . .	*Arzachel.*
T, a space bounded by a ridge of mountains to the right of R, and near the edge of the disc .	*The Sea of Nectar.*
W, a spot immediately below T	*Tracastorius.*
Y, near the edge, on the upper part of the disc .	*The Lake of Death.*
Z, to the left of Y, and near to the upper part of the disc	*Plato.*

These are the principal and most remarkable spots on the moon, and, indeed, as many as can be referred to, conveniently, within the necessary limits of this lecture. In some other scenes we shall examine several of the larger of these spots, in highly magnified views, such as are obtained with telescopes of greater magnifying power.

Scene No. XV.—The Moon's Phases.

Although the varying phases of the moon are among the most frequently observed phenomena of the heavens, they are yet the most surprising and beautiful; owing to the frequency and the strict regularity of these changes of appearance and situation in the moon, the causes of the phenomena are little thought of by an ordinary observer. If the change from new moon to full moon, and from full to new, happened only at long intervals, they would, without doubt, be considered the most extraordinary of all celestial phenomena.

In this scene the central body is the earth; the inner circle of figures the moon, in twelve points of her orbit, or as she is at each interval of about two days and a quarter, through an entire lunation. In the outer circle, the figures exhibit respectively the appearance of the moon, or her phase, to us, when in each corresponding point of her orbit in the inner circle:—thus X is the actual illumination of the moon at that point of her orbit; M is her appearance, or phase, for that point or time: so Y is the actual illumination of the moon at another and opposite point of her orbit; and N is her real phase for that point. The sun, which, in the scene, illuminates the earth and moon, is supposed to be placed at some distance on the left of the scene.

The moon being an opaque and spherical body, which appears luminous only in consequence of reflecting the sun's light, can only have that side illuminated which is at any time turned towards the sun, the other side remaining in darkness; and as that part of her only can be seen which is turned towards the earth, it is evident that we must see a different portion of her illuminated diameter at every change of her position with respect to the earth and sun.

At the time of conjunction, or when the moon is between the earth and sun (as at A in the scene), she is invisible to the earth, because her enlightened side is then turned towards the sun, and her dark side towards the earth. In a short time after the conjunction (as in the next figure below) at X, she appears to the earth like a slender crescent, to the eastward of the sun, a little after he sets; as represented by the figure M, in the outer circle. This crescent seems, as it were, to fill up, and the bright portion increases as the moon advances in her orbit; and when she has performed a fourth part of a revolution, and has arrived at B, she appears to be half illuminated; and is then said to be in her first quarter. After describing the second quadrant of her orbit, she arrives at C, and is then opposite to the sun, as regards the earth, and shines with a round illuminated disc, which we term the full moon. Her appearance at that time is represented in our scene of the moon at the full. (Scene XIII.)

After the full, she begins to decrease gradually as she moves through the other half of her orbit, and when she arrives at D (her eastern half only being illuminated), she is said to be in her third quarter, and has to us the appearance of the corresponding figure in the outer circle: thence she continues to decrease, until she again disappears at the conjunction, in the position at A, as before.

Between the third quarter and the change, or in the position from D to A, the moon is frequently visible to us during the day, even when the sun shines; she then affords the opportunity of making a very beautiful experiment. Hold a small white globe, at the length of the arm, between the eye and the moon, and if the sun shines on the globe, and it is held so that its upper part may just seem to touch the lower edge of the moon's figure, we shall see the illuminated portion of the globe corresponding exactly with that of the moon, and exhibiting a complete picture of its phase. The reason is plain — the sun enlightens the globe in the same manner as the moon; and, the figures being similar, when we place ourselves in the described situation, the moon and the globe have the same position as regards the observer, and, therefore, we must see the same illuminated portion of the one as of the other.

These different phases plainly demonstrate that the moon does not shine by any light of her own; for if she did, being globular, she would constantly present a fully illuminated disc like the sun; she is, therefore, demonstrably an opaque body.

If the moon may be supposed to be inhabited by beings like ourselves, it is evident, from this explanation of her appearances to the earth, that the earth must also present phases, precisely of the same character, to the inhabitants of the moon, as she herself does to the earth, differing only in the order in which they take place. When the moon is in conjunction, or in the position A of the scene, the inhabitants of that satellite will see the earth at *full*. When the moon is in opposition, or in the position C, the earth appears to the inhabitant of the moon to be in conjunction; he sees nothing of its disc. When the moon has advanced a little farther in her orbit, as to Y, her inhabitants then see a small portion of the earth's disc illuminated; the earth's phase is then to them what the moon's phase is to us when it is in the position X; we may be called to them their *new earth* (as we term her our *new moon*). In every part of the lunation, or of the moon's course round the earth, that portion of her disc which, in any stage, we see illuminated, is exactly the portion of the earth which to an inhabitant of the moon appears in shadow; or, which is the same, that portion of the moon's disc which to us does not appear, or is not illuminated, exactly corresponds with the portion of the earth which appears to the inhabitant of the moon to be illuminated, and, therefore, constitutes the phase of the earth, for him, in that position.

It must be understood that, in strictness, the darkened portions of the moon are not absolutely invisible to the earth, nor are the unilluminated portions of the earth invisible to the moon; a small quantity of light is reflected from the brightly illuminated part of the one, upon the unilluminated part of the other: although, in the case of the moon, we perceive this only when she is in her conjunction, or near the position A. In the other parts of her orbit her darkened portion is invisible to us, sometimes by the greater, and, therefore, overpowering light of the sun; and, at others, by the greater, and, therefore, overpowering light from those parts of herself which are fully illuminated. This phenomenon is most remarkable at the new moon, and is the subject of a distinct scene.

Scene No. XVI.—The Crescent Moon. No. 1.

The phases of the moon, and the motions that produce them, are already described in a former scene.

If we observe the moon, on a clear evening, a little after sun-set, when she is about three or four days old, that part of her disc which is not enlightened by the sun is faintly illuminated by the light that is reflected from the earth; and the horns of the enlightened part appear, as it were, to project beyond the remaining parts of the moon, as if they actually formed a portion of a sphere considerably larger in diameter than the unenlightened portion. It was formerly, and even now is sometimes, deemed a sufficient explanation of this appearance, to say, that bright objects affect the eye to a greater extent than those which are less luminous; and that, therefore, the bright part of the moon, expanding on the sight, presents the appearance of part of a large circle projecting beyond the darker portion of her disc. This phenomenon has, however, been better explained. The human eye does not view objects with sufficient distinctness at such a distance as that of the moon: and the moon is the most distant object which can present itself to us in a clear and distinct form—the sun being far too bright for our eyes; the stars too distant to be seen distinctly.

It has been suggested, and it is generally received as a circumstance greatly tending to produce this effect, that the eastern portion of the moon's surface, which is the unilluminated portion at the time of the new moon, is, in itself, considerably more luminous than the western, or that portion which is illuminated at the new moon.

Scene No. XVII.—The Crescent Moon. No. 2.

In this scene, the crescent, or new moon, is shewn, as it appears to the unassisted eye, a little after sunset. The sun has already set, and is supposed to be at a small distance below the horizon, to the right of the picture. The moon is represented at the distance from the sun at which she is seen about three or four days after her conjunction, and is travelling in her orbit towards the east, her illuminated portion increasing, in apparent width, every day.

In this scene we may observe the visible dependance of the moon's apparent figure upon the situation of the sun's light, by the circumstance of its constantly pointing, as it were, towards it. If we imagine a line drawn, connecting the points of the two horns of the moon, and a second line from the centre of the first, at right angles with it, extended onwards through the illuminated portion of the moon, this latter line will point to the place of the sun; in this scene, it would lead below the horizon on the right-hand side of the picture, where the sun is situated.

Scene No. XVIII.—The Moon Gibbous.

This scene shews the moon in a decreasing state, between that of opposition and the third quarter. It is a telescopic view of the disc, and shews it when the moon is in a position in which the evidences of its mountainous surface are most distinct.

The existence of volcanoes in the moon was maintained by astronomers in the earlier stages of telescopic observation; and the fact has received confirmation from many remarkable phenomena observed in the dark parts of the moon during the last fifty years. Dr. Herschel, whose observations on this subject are highly important, has recorded many remarkable instances. In one of these he estimated that the diameter of the burning part of the volcano was more than three miles; and he describes such appearances as frequently coming into observation, in parts of the moon, where, during the preceding lunation, there existed no indications of them. He describes the appearance of the actual fire, or eruption of a volcano, as resembling the light of burning charcoal; and he observed that it illuminated all the adjacent parts of the volcanic mountains, which became gradually more obscure as they lay at a greater distance from the crater.

Scene No. XIX.—The Waning Moon.

This scene exhibits the moon in the last stage of a lunation, and her appearance a few days before her conjunction with the sun, and consequent disappearance to us. She is seen in this stage, to the westward of the sun, near the south, in the morning, a little before sunrise.

Scene No. XX.—The Phases of the Planet Saturn.

This scene shews the phases, or appearances, exhibited by the planet Saturn in his course through his orbit. These are highly curious and interesting, and require particular attention.

The explanation of these beautiful phenomena involves the consideration of certain circumstances governing all planetary motion, which, to avoid proxility in our first general views, have not yet been mentioned; and for which this is deemed the most natural and appropriate place.

In our general views of the planetary system, we have hitherto imagined the observer to be placed above the sun, so as to see the planets revolving in orbits more or less approaching to circles. But let us now suppose the situation of the observer to be changed; let us imagine him to be placed, not above the sun, but *on one side of it,* at a considerable distance beyond the orbit of the most remote planet; he would then observe the motions of the planets performed, apparently, in nearly straight lines, or *horizontally;* for every circle, we know, may be viewed in such a direction as to appear only as a straight line. In his new position, seeing all the planetary orbits, as it were, edgewise, he would find that *these orbits are not on the same plane.* This may be familiarly explained, by saying, if a number of wires, bent into circles to resemble the orbits of the planets, are placed within one another upon a table, we shall have a representation of them, *all on the same plane;* the table on which they are placed being the plane; they are all in a perfectly horizontal position. But it has been ascertained that the orbits of the planets are not so. We will now, however, suppose *one of the planetary orbits to be horizontal,* in order to have a standard position from which to shew how much the others differ from it. Let now this horizontal orbit represent that of the earth; and as the rest all incline, more or less, from the horizontal direction, the difference between them and it is termed the *inclination of the orbit.* Astronomers always assume the orbit of the earth to be in a horizontal position; and the orbits of the other planets are said to be inclined, in proportion as their orbits are in different planes from the earth's, or the horizontal one. Thus, if the orbit of the earth be taken as horizontal, or o, then the orbit of Mercury is inclined to that of the earth, or to the horizontal position, 7 deg. 46 min. 50 sec.

		Deg.	Min.	Sec.
The orbit of Venus is inclined		3	46	9
,,	Mars	2	3	24
,,	Vesta	6	56	24
,,	Juno	14	30	30
,,	Ceres	11	48	24
,,	Pallas	38	27	46
,,	Jupiter	1	27	37
,,	Saturn	2	46	15
,,	Uranus	,,	51	3

It may be here requisite to explain what is meant by the terms, degrees, minutes, and seconds, applied to the measure of quantities or extent; as when we say that the orbit of Venus is inclined 3 deg. 46 min. 9 sec.

It has been already observed, that every circle, whether great or small, is supposed to be divided into the same number of equal parts—namely, 360, called degrees; each of these degrees into sixty parts, called minutes; and each minute into sixty parts, called seconds. This division of the circle into degrees, and the subdivision of the degree into minutes, &c., has received the common consent of geometricians; and astronomers long since perceiving circular motions in the heavens, and the whole earth being surrounded by an equal expanse of space, these divisions and subdivisions were applied to the great surrounding apparent circle.

An inhabitant of the earth always sees one-half of the starry heavens, because the earth is a mere point as compared with them: one half is, therefore, above, and the other half below us; one half is above, the other half is below our horizon. And, supposing the whole circle of the sphere to be divided into 360 degrees, the sun, the moon, or a certain planet, or fixed star, visible to us, must be a certain portion of the whole circle, a certain number of degrees and minutes *above the horizon*. If we look from the horizon to a star immediately above our heads, and, turning round, continue to look until the eye meets the horizon in the opposite point, we trace half a circle of the heavens; 180 degrees, or one half the total number of the circle. But if, beginning at the horizon, we look no farther than the *star immediately over head*, or in the *zenith*, we have traced but one quarter of the circle, or ninety degrees. If the eye travels over a ninth part of this quadrant, it has then traced a portion of ten degrees; and so of any smaller quantity or proportion of the circle.

The proportion of the circle by which the direction of one flat surface differs from that of another, is called the inclination of those surfaces to each other; and if one of these surfaces be placed permanently in any given position, as in this instance horizontally, we then speak of the inclination of the other surface, as being of so many degrees, minutes, &c. We may now proceed to examine the phenomena and phases of Saturn's rings.

To refresh the memory as to the real figure and arrangement of the body of the planet, and of its rings, we refer to the upper and middle figure of the scene. The outer band is the outer ring; the narrow black circular line shews the intervening space between the outer and inner rings; the broader space, next to this line, represents the inner ring. The broad black space, next within the broad ring, shews the distance between the inner ring and the body of the planet. The globe, which occupies the centre of the figure, represents the body of the planet itself. It will be understood that this figure shews the planet, as it were, in plan, or as it would appear to an observer situated directly over it, and looking down upon it and its ring, in a direction at right angles to the plane of the ring.

The lower figure of the scene represents the planet in several positions, or points, of its orbit. The view taken of it is such as would be visible to an observer situated at a considerable distance beyond its orbit, and elevated somewhat above its plane; the orbit, which is, really, nearly of a circular form, would appear from such a point of view elliptical, as in the figure. Knowing, as we do, that the figure of Saturn's ring also is, really, circular, we are now to consider why it appears to us elliptical, and why of different degrees of ellipticity.

As we understand what is meant by the inclination of one plane to another, in quantities that are measurable, so we can easily comprehend that lines are sometimes inclined, in the same manner, to each other, or to planes with which they are connected; thus, the axle of a wheel which rolls on the ground is a line which lies parallel to the ground; its inclination to the plane is *nothing*. In a child's toy, composed of a disc of card, having a stem passing through it at right angles to its face, and on which it is made to spin, the stem, or the axis on which it rotates, is at right angles to the plane, or table, on which it moves; it is inclined from that plane ninety degrees. The child spins the toy he calls a top, and at the commencement of its performance, while it rotates on its axis, it also makes wide circuits on the ground, during which its axis is, at first, considerably inclined to the plane on which it is moving; the top's wide revolutions gradually subside, and, at the same time, the inclination of its axis also diminishes, the angle it makes with the ground becomes less, until at length, although the top continues to rotate, it ceases to make any revolutions, and the axis is then in the position we term upright; it makes an angle of ninety degrees with the ground; it is not inclined to the plane of the ground at all. Now the axes of rotation of the planets are all of them inclined to the planes of their orbits, in a greater or less quantity, and the inclination of a planet's axis of rotation is constant; *i. e.* it preserves the same inclination in every part of its orbit. We may take the earth as an example of this; the north pole, and, consequently, the axis on which the earth makes its rotation, points always to the north, through its entire orbit. It revolves about the sun nearly in a circle, through a course of 300 millions of miles, the axis retaining the same direction, *viz.* north and south, through the entire orbit, and this permanently.

We can now consider the planetary motions in further detail than we did in our general view; certain peculiarities of each can now be explained, which before would have been inconsistent with the necessary perspicuity.

The planets move in orbits more or less elliptical, although not differing greatly from circles. These orbits are inclined to the plane of that of the earth by a greater or less difference, as we have already stated; and the planets themselves have their axes of rotation inclined to the planes of their orbits, respectively, in different angles. This latter circumstance will be explained in reference to each planet, at the close of our views of the system.

The axis of rotation of the planet Saturn is inclined to his orbit about sixty degrees; and the plane of his ring is at right angles with, or ninety degrees from, his axis; so that it has an inclination to the plane of the earth's orbit of nearly thirty degrees.

Now, the axis of Saturn, and, consequently, that of his rings, constantly keeps the same direction during the entire revolution of the planet about the sun; and as the performance of this revolution occupies nearly thirty years, the sun shines for about fifteen years together on one side of his ring, and then for fifteen years on the other side. But twice, in the thirty years of his revolution, there must be an instant when neither side of the ring is enlightened—when only the outer edge of the ring is presented to the sun; that is, when the sun ceases to shine on one side, and is just about to shine on the other.

The lower figure of the scene, shewing the planet in eight points of its orbit, will illustrate this. The sun is seen in the centre; and next, immediately round it, is shewn the earth in eight points of her orbit, corresponding with, and opposite to, the eight positions of Saturn. When the planet Saturn is at that point of his orbit marked A, the earth sees the body of the planet, with the edge of its ring crossing it like a bright line, as it is separately shewn at the small figure A of the side columns of figures. When Saturn has advanced to the point B of his orbit, the sun shines on the under side of his ring, and the earth sees the planet and the ring, as shewn at B of the small figures. When the planet has arrived at C, the sun still enlightens the under side of the ring, and it appears to the earth, as shewn at C, the elliptical figure of the ring being wider than it was in any part of its orbit from the point A. When it has arrived at the point D, the sun still shines upon the under side of the rings, and it appears as at D. When it has travelled on to the point E, it is again in one of those positions in which the sun does not shine on either side of the ring; as it was at A, to which point in the orbit it is opposite. In this position the ring is again seen as a bright line crossing the body of the planet, as shewn in the small figure at E. At the point F, in its orbit, the planet presents nearly the appearance it did when at the opposite point at B, as to the quantity of its ellipticity; but the sun now shines upon the upper side of the ring; the appearance of the planet and ring is then as shewn at the small figure F. When arrived at G, the sun is then shining more fully on the upper side of the ring; it is then at its other point of greatest ellipticity, the first being at its opposite point C, and appears as at G of the small figures. At H, the sun continues to shine on the upper surface of the ring, but the ellipticity is reduced; it appears as in the small figure at H. At A, the planet has completed its revolution through its entire orbit, and has exhibited, in its phases, all the gradations of ellipticity between the straight lines at the opposite points at A and E, and the open ellipses at the opposite points, C and G; the proportions of the longer and shorter diameters of the ellipse at its points of greatest apparent width, being as nine to four.

The remarkable depression at the poles of Saturn, and his consequent singularity of form, which we have already described, are, in part, attributed to his rapid revolution about his own axis (about ten hours and a quarter); it is also, in part, attributed to the attraction existing between his body and his ring, which must constantly lessen the gravity of his equatorial regions, and dispose them to be thrown forward by the rapid rotation of the planet itself.

Scene No. XXI.—The Relative Sizes of the Planets.

This scene represents the relative appearance of the planetary bodies, in their bulk, or apparent diameter. The relative appearance of the sun, as regards the figures of the planets in this scene, would be that of a globe of nearly eighteen inches in diameter; this dimension is precisely that of a large-sized artificial globe, and can, therefore, be easily pictured to the imagination. With a globe of this diameter to represent the sun, the planet Mercury (which, it will doubtless be recollected, is that nearest to the sun) would assume the dimensions and appearance shewn in the small figure marked A in the scene. The figure, marked B, represents the planet Venus of her proportional size; C shews the earth and our moon, also of their proportional sizes; and D the planet Mars. The upper part of the scene represents the planet Jupiter. The lower figure, Saturn; his rings bearing their proper relative dimensions and distances from the planet. The figure, marked H, on the right of the scene, shews the relative size of the planet Uranus.

The imagination will be greatly assisted in the estimate of the character and extent of the system of planets, by a short statement, in approximate numbers, of the relative sizes of the planets, and their proportional distances.

The proportional magnitude that Mercury bears to the earth is one-fifteenth; its proportional distance from the sun, as regards the earth's distance, is four-tenths. The relative magnitude of Venus to that of the earth is nine-tenths; its proportional distance from the sun, seven-tenths that of the earth. The relative magnitude of Mars to that of the earth is one-sixth; its proportional distance from the sun, once and a half that of the earth. The magnitude of Jupiter is 1400 times that of the earth; its distance from the sun about five times and a quarter that of the earth. The relative magnitude of Saturn is as 1000,—its proportional distance from the sun, about nine times and a half,—that of the earth. The planet Uranus is ninety times the magnitude of our planet; its proportional distance from the sun more than nineteen times that of the earth. The real magnitudes of the four asteroids are but imperfectly known. The magnitude of the moon is one-forty-ninth that of the earth. The magnitude of the sun is 1,367,000 times that of the earth.

PART II.

Distances of the Planets.

We know that the sun's distance from us is nearly ninety-six millions of miles; but, as we are not accustomed to traverse, or to apply any mode of measurement, to a million of miles, we are not enabled, by our assurance of the fact, or the habitual and fluent repetition of the numbers, to form any distinct notion of the actual extent spoken of. When we speak of an inch, a foot, a yard, we attach a distinct idea to the expression; we understand the extent, for we can see it and measure it. If we speak of a mile, of ten miles, a hundred miles, we also form distinct notions of the distance: in the case of the mile, we are perfectly clear, for we can frequently *see it* at one glance; we can, at all times, estimate its extent by its number of yards and feet. Of ten, or a hundred miles, the mind is tolerably well satisfied; they are distances we frequently travel; extents over which we can, without much effort, apply the preconceived scale of a mile, and we are satisfied with the result; we *see* and feel that it is an extent over which we can easily pass in the business of life. In the case of distances of *thousands* of miles, those alone who have performed long sea voyages make any clear estimate. A person sailing from England to New York forms distinct notions of the distance of one, two, three, or four thousand miles, not, as we do in the case of a single mile, by imagining the distance to be spread before him, but by the distinct impression that he has travelled at a certain known rate during a certain number of days. A traveller of this class forms a clear idea even of the circumference of the earth, the distance to which, as it may be said, his eye is accustomed; he can multiply to the necessary extent; and be satisfied, without painful effort, that he estimates the distance truly. But the imagination is unequal to any distinct idea of the space occupied by a hundred millions of miles, of the appearance it would exhibit, or how it could be placed within the scope of our faculties of sight and estimate. We will endeavour, in some degree, to familiarize the idea of the extent of this enormous distance—namely, a hundred millions of miles—by the easiest means we possess; by applying to it our known terms of distance and rate of travel.

If we travel at the rate of ten miles per hour, and continue the progress, without intermission, during each twenty-four hours of the day and night, for the space of fifteen weeks, we shall have travelled over somewhat more than

25,000 miles; a distance equal, in extent, to the entire circumference of the earth. It is not difficult to imagine this voyage; and, by considering the matter in this way, we can even make a tolerable estimate of its extent. But to reach the sun from the earth, which, in approximate numbers, is ninety-six millions of miles, it would be necessary that we should travel at the same rate, without any intermission, and in a direct line, during more than 1100 years!

The instrument, or machine, called the orrery, is an ingeniously contrived piece of mechanism, intended to represent the planetary motions; but, although generally of very accurate construction and workmanship, it fails to effect the intended purpose; namely, to give distinct ideas of the appearance and motions of the planets. From what we have just seen of their motions and their distances from each other, it is evidently impracticable to represent faithfully either one or the other; but, to make a practical orrery, it is necessary to shew both. As an accurately constructed toy, the orrery has merit; but, as a medium of early instruction in the science, its pretensions seldom justify the costly character of the machine.

The impracticability of forming a piece of mechanism which shall exhibit any similitude to the relative distances and magnitudes of the planets, must, therefore, be evident; but there have been several arrangements of a mixed nature, which perfectly succeed in giving correct first ideas of these movements and distances, the cost of which is inconsiderable, the scale gigantic, yet perfectly natural, and the effect more striking than any mechanical contrivance could produce. We shall describe one of these arrangements, which has frequently been put in practice by the author, has been found extremely attractive, and to the perfect satisfaction both of the agents and the spectators, or audience, of the exhibition and lecture, for it partakes of both characters.

The Animated Orrery.

A few of the most active and intelligent boys of a school, previously instructed in the simple elements of the planetary motions, are selected, and placed on the most extensive level their usual play-ground affords, with a few words of admonition and advice on the fidelity and precision expected from those who, in their own persons, are to imitate the motions of the planets. Twelve boys are selected, and a card is delivered to each, on which is legibly written the circumstances of one of the eleven planets, or of the sun: such as, in the case of a planet, its distance from the sun; its diameter; the period of its revolution in its orbit; the period of its rotation on its own axis; the inclination of its orbit to the ecliptic, and the inclination of its axis of rotation to its orbit; its bulk, or magnitude, compared with the sun; and whatever other circumstances may particularly distinguish it, and which, from the scale of the exhibition, we may be justified in introducing. A central point of the ground is then fixed on; and from that spot, as a centre, the cardinal points of east, west, north, and south, are represented by a distinguishing mark, or wand, on the borders of the ground. The boy who holds the card of the sun is stationed on the central point just determined. A gardener's common reel, with a line, is then fixed in the place of the sun; and the boy holding the card of Mercury, is called on to go forward, and trace, with the line—the reel, or sun, being in the centre—the orbit of Mercury, his planet; which he performs from his own sources of information: having done this, he is to place himself on any point on the circle of his orbit, and remain at rest. The bearers of the cards of the other planets are then called in turn, in the order in which they stand from the sun, and required severally to describe their own orbits, and take their stations, facing inwards, or towards the sun. A small flag, or banner, is now delivered to each boy, on which is inscribed the name of the planet he represents.

The director of this living orrery now stations himself, with the spectators of the exhibition, a few feet on the outside of the orbit of the most distant planet, Uranus, and on its northern side. By the simple military word of command, *Attention*, the performers are reduced to silence and readiness to put themselves in action; and each is desired to place himself on that point of his orbit which is exactly between the director's station and the sun, and facing inwards, or towards the sun; the word of command, *To the west* FACE, is then given, when each person, facing to *the right*, stands looking towards the *west*, and, displaying his banner, remains steady. The orrery, if so it may be called, is now prepared; it only remains to put it in motion.

Mercury is desired to march steadily and slowly on the line of his orbit, until he has performed one entire revolution and a half, when he will have arrived at the point opposite to the director's station, where he halts; he is then asked, in audible tones, simply, what planet he represents; to which he answers distinctly: and he is desired to say, by what peculiarities of distance, motions, &c. he is distinguished: these points being answered, he is directed to move on, about twenty paces, and halt, remaining steady for further orders. The next planet, Venus, is then called upon to perform the same operations; and having, in the same manner, passed, what may be termed, his examination, he also moves on about twenty paces, halts and remains. The rest, in their turn, go through the same ceremony; and when the last, or most remote planet, has thus passed in review, the orrery may be said to be *set*. Each member of it is acquainted with his path, or orbit, and is master of his portion of the subject; each is again desired to move round in his orbit, and mark the place of the nodes of his planet, which will be presently explained. He marks these points by a staff, and remains at the place.

Now, at a given signal, all the performers step, or, rather, march with a firm and measured pace, in the direction in which they were previously placed, from the west towards the east; and the first simple representation of the planetary system is complete, and is effected in a manner pleasant to the observer, and instructive, as well as amusing, to the performers. These arrangements, simple as they are, repeated at intervals, and changing the distribution of the planets among the boys, will fix in the memory clear and sure ideas on the subject, which will not be easily forgotten; and will, in many cases, induce an application to the closer study of the science, which, but for these distinct first notions, acquired during the hours of recreation, and almost without effort, would have been deemed uninteresting, and, therefore, irksome.

This simple arrangement will successfully familarize the appearances of the planetary motions, and form a very practicable approach to a strictly proportional display. For a school amusement, what has been described may, at first, be deemed sufficient; various points of detail, which will suggest themselves as we draw to the conclusion of this lecture, may be added progressively; for the extension of this mode of representation is unlimited. By the introduction of gravelled paths for the orbits; of soldiers marching to music, and bearing gilded balloons, to personate the planets; of an elevated pavilion to represent the sun, in which the observers might be placed; by the occasional visits of comets, in the persons of fleet runners, suitably attired, dashing across the system, in elliptical orbits previously marked out for them, and returning into the distant regions beyond its bounds; by conjunctions, eclipses, the differences between the real and the apparent motions, with various minor circumstances, we might arrange an exhibition of much higher interest than can be expected within the limits of a lecture-room, or a theatre.

Mechanical orreries shew the respective periods of revolution of the planets; but to give motion to a machine of this class, capable of representing their relative sizes and distances, is utterly impracticable. One example will suffice to shew this. If a scale of representation were chosen, which should have the sun of two feet in diameter, the diameter of the planet Mercury must be that of a small pin's head, at the distance of eighty-two feet; while the diameter of Uranus must be about three-fourths of an inch, at nearly the distance of a mile: the magnitudes being, in both cases, invisible at those distances. An exhibition of this kind should, as far as possible, be constructed on a scale which will allow all the objects composing it to be visible from the sun's place. The most comprehensive and faithful approximating representation of the planetary distances and diameters, is one in which the distances are familiar to us; and the diameters such as come within our daily observation. Any model in which the parts are of diminutive dimensions, perplexes the mind, and injures the desired impression; while the magnificence of nature is on a scale too vast for the imagination without studied preparation: the only effective middle course seems to be, to choose the largest possible scale within the limits of our distinct perceptions.

The following distances and magnitudes have been imagined, in order to give a familiar description, and clear idea of the planetary system; and the plan has been found satisfactory and useful.

Let the sun be represented by the dome of St. Paul's cathedral; its diameter at the base being 108 feet.

The figure of Mercury, in due proportion to 108 feet, assumed as representing the bulk of the sun, would be a ball of five inches diameter; it would be at its proper proportional distance from the sun if placed at one mile from St. Paul's dome; its orbit would pass through all places at that distance, say Somerset-house, the Tower of London, and the Borough of Southwark.

Venus would be a ball of thirteen inches diameter, placed at the distance of one mile and a half from St. Paul's, for instance, at Westminster Abbey.

The earth would be properly represented by one of our usual twelve-inch terrestrial globes, placed at the distance of two miles and a half from St. Paul's, as at the Queen's palace at Pimlico. The moon, a ball of nearly three inches diameter, revolving about it at a distance of thirty feet.

Mars would be a ball of nearly six and a half inches diameter, placed at the distance of three miles and a half; say on Highgate-hill, or at Kensington-palace.

The asteroids, Vesta, Juno, Ceres, and Pallas, do not differ greatly from each other, either in size or distance; they would be properly represented by balls of somewhat more than a quarter of an inch diameter, at a little more than six miles from St. Paul's; as at Blackheath, Dulwich, or Tottenham.

Jupiter would be a globe of nearly eleven feet in diameter, and placed at twelve miles from St. Paul's; as at Kingston, in Surrey, or Romford, in Essex.

Saturn would be a globe of nine feet six inches diameter, surrounded by a ring of twenty-two feet diameter, and placed at the distance of twenty-one miles and a half; as at Windsor, in Berkshire, or at Gravesend, in Kent.

The planet Uranus, would be a globe of four feet six inches diameter, placed at the distance of forty-three miles from St. Paul's, as within a few miles of the sea, in the neighbourhood of Brighton.

It may assist the imagination in forming a notion of the actual distances of the planets from the sun, to determine the time required to carry a cannon-ball, at its usual rate of flight, from the several planets to that luminary. Assuming the rate of motion of a cannon-ball to be, in round numbers, 1000 miles an hour, or about seventeen miles per minute; to traverse the distance between the sun and Mercury would require its uniform flight during about four years and a quarter. From the sun to Venus, eight years; from the sun to the earth, nearly eleven years; to Mars, about sixteen years and a half; to Vesta, Juno, Ceres, and Pallas, twenty-eight years; to Jupiter, fifty-nine years and a half; to Saturn, 102 years; and to Uranus, 205½ years.

Scene No. XXII.—The Sun as seen from the different Planets.

In this scene we have a representation of the proportional diameter, or appearance, of the sun's disc, as seen from the different planets. Suppose the larger figure to represent the sun as seen from the planet Mercury; the second, or next smaller figure, would shew the proportional appearance of the sun from Venus; the figure next above this, the proportional size of the sun as seen from the earth; the next above this, is the proportional size as seen from

Mars; the next, as seen from Jupiter; and the smallest, as seen from Saturn: from Uranus, the sun appears a diminutive point.

Scene No. XXIII.—The Constellations of the Northern Hemisphere.

The immense and splendid scenery of the firmament, which surrounds us on all sides, and which has been already so much dwelt on in the first scene on the fixed stars, now comes under our immediate consideration. It may be readily imagined, that the splendour of the scene of the starry heavens, in appearance perpetually revolving around the earth, must very early have commanded the earnest attention of mankind; and that, long before any systematic cultivation of science, men must have remarked the regular changes of situation, in regard to the earth, of the stars apparently fixed in the heavens, and that, though they appear unequally and irregularly dispersed over it, they must, in some measure, have classed them, and reduced them to something like order, and that the most brilliant would chiefly attract their attention; and hence, that such an arrangement of the whole would be made as to enable the learned to hold intercourse on the subject, without immediate reference to the objects themselves. In what age of the world the artificial arrangement of the stars into constellations took place, is not known with precision, but it is most certain that it was antecedent to any distinct historical record.

Before the discovery of the telescope, even learned men believed the number of the stars was limited to a few hundreds; but the number visible to the naked eye differs according to the powers of the observer's sight. A telescope of very moderate power, however, shews us ten times as many stars as can be seen by the unassisted eye; and, as the magnifying power of the instrument is increased, the number of the stars seen also increases, till, as far as we can discover, the mass seems countless. Galileo, the inventor of the telescope, formed the design of composing a map of the stars, as they appeared to him when seen through his best telescopes; but, at the commencement of his task, counting twenty-one distinct stars in a space he had supposed, by observation with smaller telescopes, to be occupied by one spot of dim light, and counting five hundred in another spot of about one degree square, he gave up the attempt. But the discoveries of modern astronomers, and more particularly of Herschel, have given us a prodigious accession of knowledge in regard to the stars; a magnificent field of speculation is now opened to astronomy, in which stars and systems, extension of space and variety of arrangement, seem multiplied to infinity.

All the stars, known to the ancients, were those which are visible to the naked eye. These, to persons unaccustomed to seek and observe them, are only about 2000 in both hemispheres; so that, at one view, they could only see about 1000. These stars are, for the most part, disposed at irregular distances; but, in several places, we find them in clusters and nebulæ (luminous spots of cloudy appearance). Of these nebulæ alone, Herschel observed and has given a catalogue of nearly 3000: some of them consist of clusters of stars, visible to the naked eye; others, of stars visible by the help of a telescope of moderate powers; others, of stars visible only by the aid of powerful instruments. To whatever part of the heavens a telescope is directed, we find a multitude of stars which are invisible to the naked eye. In some cases, groups which, to the eye, seem to consist of five or six stars, to the telescope, exhibit more than 200. The whole number of the stars in Orion (that most beautiful of all the constellations), appears to the eye, under ordinary circumstances of weather, to be only about twenty; by the help of a telescope we discover 2000. The bright irregular stripe in the heavens, called the *Milky way*, was closely examined by Herschel, who, in the space of a quarter of an hour, saw 116,000 stars pass through the field of view of his telescope. It is evidently impossible to imagine any distinct bounds to the numbers of the starry host; there is, indeed, abundant reason to believe that there exist numberless stars, too minute, or too remote, to be discovered by the most powerful telescopes that have yet been constructed; and that the imperfection of our instruments of observation is the limit of our knowledge.

On account of the apparently different magnitudes of these heavenly bodies, they have been arranged in several classes, or orders. The largest, or those which appear so, are called stars of the *first* magnitude; the next to them in brightness, stars of the *second* magnitude; and so on to the *sixth* class, which are the smallest that are distinctly visible without the assistance of a telescope. This mode of classification was made by the earlier astronomers long before the discovery of the telescope; such stars as cannot be seen without that assistance, are called *telescopic stars*. In many of the constellations, one or more stars are found, which, by their superior apparent size and brilliancy, originally obtained the first notice; and these have, in most cases, some distinguishing name given to them. The other stars, beginning with the largest of them, are distinguished among themselves, by being respectively marked with a letter of the Greek alphabet. The largest being marked α (*Alpha*), the first letter in the alphabet; the next in size, β (*Beta*), the second letter; the third in size, γ (*Gamma*), the third letter; and so on. If the number of stars in a constellation exceeds the number of letters in the Greek alphabet, the letters of the Roman alphabet are taken in the same way to mark the additional numbers. By this mode of classification, or registering, we are enabled to refer to each star visible to the naked eye, without mentioning more than the name of the constellation, and, as the case may be, that of its principal star, or the Greek letter which marks its class.

Astronomers discover occasional changes among the stars, which forbid our calling some of them *fixed*, in the strict meaning of the term. About 160 years before the Christian era, Hipparchus, the most celebrated of the ancient astronomers, while occupied in a course of observations on the stars, was surprised to find one remarkable star suddenly *disappear*. Desirous to furnish posterity with the means of registering any similar occurrence, he determined on the important and laborious task of forming a complete catalogue of the stars; this catalogue contained the places of upwards of 1000; but several of the stars, so observed and noted, are not now to be found, while others are at present visible which are not included in the ancient catalogue. Some stars have gradually increased in brilliancy; others, which were formerly variable, now shine with a permanent and steady light; others, have decreased in brightness. It is yet more remarkable, that a considerable number of stars exhibit a periodical change in their appearance, both in apparent size and brilliancy.

The number of stars noted in the ancient catalogues, was gradually much extended by the observations of astronomers in succeeding ages, assisted, as they were, by the continual improvement of their instruments of observation. Flamstead, in the beginning of the last century, completed a catalogue in high estimation, containing the names of nearly 3000 stars. Since the commencement of the present century, astronomers have formed catalogues yet more extensive. The catalogues of Herschel, and other modern observers, carry the numbers much higher still, and shew us that, to telescopic observation, their number is altogether beyond our power of enumeration.

The scene is a view of the figures of the constellations of our northern hemisphere, with the appearance called the Milky way.

The earliest observers of the heavens did not fail to discover that, at particular times of each evening throughout the year, certain stars seemed to rise, and others to set; and that these appearances varied through the year, and regularly returned. Now, for the convenience of observation, and more especially for ascertaining what appeared to them to be the *motion of the sun*, it became essential to have certain fixed stars—certain stars from which to mark and describe his progress. By a rude measure of time, they obtained twelve points of the whole circle within their view; the knowledge of twelve stars from which to note their observations. This great circle they called the *Zodiac*, from a Greek word (*Zodion*), signifying an animal; because, having classed the stars in each of these twelve parts into one collection, or constellation, they called most of them after the name of some animal. These distinctive names have been, from time to time, altered by different nations of antiquity, but are now arranged as follows:—In English—the Ram, the Bull, the Twins, the Crab, the Lion, the Virgin, the Balance, the Scorpion, the Archer, the Goat, the Waterbearer, and the Fishes. In Latin, and in the same order—Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, Pisces. The Latin names are most generally used in our works on Astronomy, and in maps of the constellations.

This seems a singular selection of figures for such a purpose; but as these twelve figures were intended, simply, to denote the twelve divisions, or months of the year, it is easy to conceive that the choice was governed by some particular circumstance relative to the earth, in the months to which they belong. Thus, as the sun is always seen in summer among certain stars, these were included in a constellation, which they termed the Lion, whose fierceness was intended to designate the great heat of that season; one was called the Archer, representing the season for hunting; another, the Virgin, a reaper of corn, the season of the corn harvest; and so on. The zodiac, then, is to be considered an imaginary belt, or circle, round the starry heavens surrounding us; and supposing this circle to be divided into 360 degrees, each of the twelve parts of the zodiac will contain thirty degrees of the entire circle. The zodiac, in its breadth, takes in a band, or belt, of stars of sixteen degrees; eight degrees broad on each side of the line which marks the apparent path of the sun, because in that width are comprehended the paths, or orbits, of the planets.

Along the middle of this belt of sixteen degrees in breadth, therefore, lies that circle which, to us, appears to be a path described by the sun in his progress about the earth. But, if we were stationed at the sun, it would be the path which the earth would appear to describe in its annual motion round the sun; it would appear to be what it really is. This circle, the apparent path of the sun, but real path of the earth, is called the *ecliptic*.

It will be understood that, as the sun, in its apparent motion round the earth, seems to arrive at the same point, or star, at the beginning of every year, and at another star at the beginning of every month (with a slight deviation), the astronomer is enabled, by subdividing this great circle into degrees, minutes, and seconds, accurately to describe its apparent periodical motion; and thus, knowing the point at which the sun will seem to arrive at each day, hour, and even minute and second, he is enabled to calculate with certainty the precise motion of the earth—the exact orbit in which it moves; for, in fact, the same circle will appear to be described, whether the motion be in the sun, or in the earth. *The ecliptic among the stars, and the earth's orbit around the sun, therefore, are on the same plane;* for, with respect both to the sun and the earth, each, as seen from the other, appears to describe the circle called the ecliptic; seen from the earth, it is called *the apparent path of the sun;* seen from the sun, it is *the apparent path, or orbit, of the earth.*

It is important to a distinct apprehension of the uses of the grouping of the stars into constellations, and more especially of those which compose the zodiac, that the orbit of the earth and the ecliptic should be understood to be on the same plane; shewing, that the earth's motion in her orbit is intimately connected with the zodiac and its divisions, which belong to the ecliptic.

All that region of the heavens, which is on the northern or upper side of the zodiac, was divided by the ancients into twenty-one constellations, each of which is composed of many stars; and that region which is on the lower, or southern side of the zodiac, was divided into fifteen constellations: so that the stars of the whole sphere, including the twelve constellations of the zodiac, were, by them, arranged into forty-eight constellations. Certain stars, however, whose appearance made them of less importance, or whose relative positions rendered it difficult to include them in any of these constellations, were omitted in this arrangement. Of these, new constellations have been formed, from time to time, by succeeding astronomers; and now the whole extent of the heavens is arranged into 108 constellations, containing nearly 4000 stars.

The constellations of the zodiac are twelve in number, and contain nearly 1200 stars. They are situated in the following order:—

Aries	the Ram, contains	42 stars.
Taurus	the Bull	207
Gemini	the Twins	83
Cancer	the Crab	85
Leo	the Lion	93
Virgo	the Virgin	117
Libra	the Balance	66
Scorpio	the Scorpion	60
Sagittarius	the Archer	94
Capricornus	the Goat	64
Aquarius	the Water-bearer	117
Pisces	the Fishes	116

We have now to point out the relative situations of the constellations, in order to be able to find them when occasion requires, and to examine them separately, so as to become acquainted with, at least, the principal stars individually.

There is no particular constellation, or star, in the heavens, so remarkable in its appearance, or so singularly situated with respect to the rest, as to entitle it to the distinction of being first described; but as the constellation Ursa Major, or the Greater Bear, is always above our horizon, and because it is one of the most conspicuous constellations in our hemisphere, and, to a certain extent, popularly known even to persons ignorant of astronomy, we shall describe it in the first place, and employ it, as a base or standard, from which to trace out the rest. A glance at the scene before us, and a subsequent reference to the separate constellations which form a collection of auxiliary scenes to it, will afford a first and general idea of the subject. A highly useful extension of the knowledge thus gained, may be obtained by following, what is termed, the method of the *alignment* of the stars. This consists, simply, in determining the place of a star that is *required*, by drawing an imaginary straight line through two others that are *already known*. In the practice of this method it is useful to take a thread in the hands, and, holding it up, to stretch it, and make it apparently cover the known stars; a prolongation of the straight line formed by the thread, will be then an index, or pointer, to the star sought.

Scene No. XXIV.—The Constellation Ursa Major.

The constellation Ursa Major is composed, at first sight, of seven conspicuous stars, four of which are disposed in a rectangular figure, and form the body of the animal; while three others, arranged in a slight curve, which is an extension of the imaginary upper line, form the tail. The two large stars marking that side of the body which is farthest from the tail, and which may be considered the breast of the bear, are called the *pointers*, because a line drawn through them will, at all times, point very nearly to the star which marks the North Pole, and which, in an early part of the lecture, was denominated the *Pole Star*. The knowledge that the distance from one of the *pointers* to the other may be taken, approximatively, as equal to five degrees, and the apparent diameter of the sun, or moon, as equal to half a degree, or thirty minutes, will furnish a young observer with a useful scale, by which to measure angular distances among the stars.

We have stated that a line drawn through the *pointers* of Ursa Major leads to the pole star; this line reaches the pole star, at a distance from the pointers of about five times their distance from each other, or twenty-five degrees.

The pole star is not *precisely* the place of the pole; it is distant from it about one degree and a half.

Scene No. XXV.—Draco—Ursa Minor.

The pole star forms part of the constellation Ursa Minor; it is situated at the extremity of the tail: the figure of this constellation has nearly the same character as that of Ursa Major, and lies in a direction almost parallel to it, but in an inverted position.

Draco.

The constellation Draco separates the figures of Ursa Major and Ursa Minor by a portion of its tail, which has its extremity between the upper pointer of Ursa Major and the pole star; it sweeps round in front of Ursa Minor, and, after three involutions of its body in contrary directions, by which it encloses it on three sides, terminates in four considerable stars, forming its head, at about the same distance from the feet of Ursa Minor as that which separates the latter from Ursa Major.

Scene No. XXVI.—Lynx.

This constellation belongs to the northern hemisphere; it is fifty degrees in length, or extent, in the eastern and western direction; and about twenty-five degrees in its breadth, or extent, in the northern and southern direction. It has no stars of the first, second, or third magnitude; three of the fourth; and several of the smaller magnitudes.

Scene No. XXVII.—Auriga.

Between the figures of Gemini, and that of Perseus, and occupying the whole intervening space, is the constellation Auriga; it is composed of five principal stars, disposed in an irregular pentagon. This constellation may also be found by drawing a line, connecting the two stars which form the back of Ursa Major, and continuing it, in the direction of the head, to the distance of about forty degrees. The figure of the constellation is that of a man, who seems to be seated, and to hold on his left arm a goat and her kids, and in his right hand a bridle, as if belonging to horses; these, however, are not drawn with the figure.

That portion of the heavens which is comprised between the constellations Gemini, Auriga, Perseus, Andromeda, Cassiopeia, and Ursa Major, does not contain any remarkable stars; it is principally occupied by constellations of minor appearance, composed, by modern astronomers, of the stars which were not classed by the ancients—as Lynx, Camelopardalis, and a few others.

Scene No. XXVIII.—Perseus.

A line passing through the three great stars of Andromeda, and, continued about fifteen degrees farther, marks the head of the adjacent constellation, Perseus. Near to this, at about ten degrees distance, towards the north, is a remarkable star, forming the head of Medusa, in the same constellation. A line, drawn from the upper pointer of Ursa Major, diagonally, to the opposite corner of its square, if prolonged in the direction of the upper pointer, will also lead directly into the constellation Perseus, near to the Medusa's head.

Scene No. XXIX.—Andromeda.

A line drawn through the pointers of Ursa Major and the pole star, if extended beyond Cassiopeia, falls into the middle of four large and remarkable stars, arranged nearly in a square, each side of which, or the distance from star to star, is nearly fifteen degrees, or three times that of the pointers of Ursa Major, from each other. The most easterly of these four stars marks the head of the adjoining constellation, Andromeda; the remaining three, the constellation Pegasus. A second star, of the same size and appearance, and at about fifteen degrees distance, farther to the eastward of it, marks the girdle of the figure Andromeda; a third star, of the same size, about the same distance beyond the last, and in the same direction, marks the feet of Andromeda.

The figure of Andromeda is that of a woman, unclothed to the girdle, her arms extended, and each attached to a fragment of rock by a chain.

Scene No. XXX.—Cassiopeia.

Cassiopeia lies directly opposite to Ursa Major; the feet of Cassiopeia are directed towards the head of that constellation, the interval between them being divided into nearly equal portions by the pole star. The figure is that of a woman seated on a chair, slightly clothed, with both hands raised, holding in the left, a branch of palm, and in the right, a portion of her head-dress.

Scene No. XXXI.—Pegasus.

This constellation lies near the head of the figure of Andromeda. The figure of Pegasus is the anterior half of a horse, with wings on the shoulders; the hinder parts of the animal are not seen. Immediately before the head of Pegasus is the head and neck of a horse.

Scene No. XXXII.—Cygnus—Lyra.

Above Cassiopeia, and close to the shoulders of Draco, is seen Cygnus, and adjacent to it, on the western side, is Lyra. The figure of Cygnus is that of a swan flying, the wings extended, and the feet drawn up under the body. Lyra is a very small constellation; its figure is that of the ancient Greek lyre.

Scene No. XXXIII.—Cepheus.

This constellation stands between Cassiopeia and Ursa Minor. A line, drawn through the pointers of Ursa Major to the pole star, and prolonged beyond it to about its distance from the pointers, passes through the whole length of the constellation: the feet of which come down to the pole star. The figure is that of a regal personage, seated, having a diadem on his head, a sceptre in his right hand, with the left hand extended. The extent of the figure is much greater than that of Cassiopeia; it is situated behind her chair, with the face directed towards her.

Scene No. XXXIV.—Hercules.

This constellation is situated in the northern hemisphere: its length is about fifty degrees; its breadth about forty-five degrees. It has no star of the first magnitude; none of the second; eight of the third; twenty of the fourth; and many of the smaller magnitudes.

Scene No. XXXV.—Bootes.

A line drawn through the two hinder stars of the tail of Ursa Major leads to this constellation. The figure is that of a man, who seems to walk towards Ursa Major; he holds a club in the right hand, and with the left hand he seems to lead and urge on two hounds: this hand is placed near the tail of Ursa Major.

Scene No. XXXVI.—Ophiucus.

This constellation is situated on the equator; its extent is about thirty degrees in length, and its width about ten degrees. It has no star of the first magnitude; two of the second; five of the third; twelve of the fourth magnitude; and numerous smaller stars.

Scene No. XXXVII.—Aquila—Antinous.

This constellation, also (for the two figures form but one), is situated on the equator; it extends over a space of about twenty-five degrees in length, by about thirty degrees in breadth. It contains one star of the first magnitude; none of the second; ten of the third; six of the fourth magnitude; and several of the fifth and sixth.

Scene No. XXXVIII.—Aries.

Immediately below the back of Andromeda, at the distance of about ten degrees, is the constellation Aries, one of the zodiac, and (for reasons which will presently be given) the first in order of the twelve signs. Towards the north-east, and over the back of Aries, is Musca; and, directly above this, Triangulum. The figure of Aries is a ram, in a sitting posture, having one foot extended forward, the other three drawn up under the body, the head turned, and looking back. Musca, the fly, is represented by that insect in its most common form. Triangulum, the triangle, is simply a small triangular figure, of little breadth.

Scene No. XXXIX.—Taurus.

The constellation, Taurus, is the second in order of the twelve signs of the zodiac: it is one of the most conspicuous in the heavens, and easy to be distinguished. The figure is that of the head, neck, shoulders, and fore-legs of a horned bull, with a portion of the back: the figure terminates where the hinder parts of Aries begin. The tip of one horn touches the right foot of Auriga; the foot of Perseus nearly touches the bull's shoulder. Taurus is brilliant in large stars; but is chiefly remarkable for two bright clusters, which are of very distinct appearance, and are readily found by the naked eye. One of these, called the Pleiades, is the cluster vulgarly known as the seven stars; another is called the Hyades. The first of these is situated in the neck of the bull; the latter in his face.

Scene No. XL.—Gemini.

If a line be drawn from the first star of the tail of Ursa Major, nearest to his body, and continued through the body diagonally, it will, at a distance of about five times the diagonal of the body of Ursa Major, or twenty-five degrees, point out the place of the constellation Gemini. This is the third constellation of the zodiac, and its stars form a quadrilateral figure, of tolerable distinctness. The figure given to this constellation is that of two children, seated close to each other; one of them holding in his right hand a small club, the other a dart.

Scene No. XLI.—Cancer.

Immediately behind Gemini is the constellation Cancer, the fourth in order of the twelve zodiacal divisions; it contains few stars, and those not remarkable for their size or brilliancy.

Scene No. XLII.—Leo.

Leo is the fifth in order of the constellations of the zodiac. It is placed farther behind Gemini than Cancer, and consists of several remarkably bright stars, disposed in a quadrilateral figure; it is supposed to represent a lion in the act of running; his direction is towards the constellation Gemini. A line drawn from the pole star, continued through the pointers of Ursa Major, and extended about twenty degrees, passes into this constellation.

Scene No. XLIII.—Virgo.

Virgo, the sixth constellation of the zodiac, is placed at about twenty degrees behind the body of Leo. Virgo occupies a large space in the heavens, but is chiefly remarkable for one very brilliant star. The figure represents a female reaper, who holds in her left hand an ear of corn; the hand is marked by a bright star of the first magnitude. A line drawn from the upper pointer of Ursa Major, diagonally through the body, leads to this star. The constellation Virgo is the last of the zodiacal signs, which are shewn in Scene XXIII. of the constellations of the northern hemisphere. The remaining six, which follow in succession, are shewn in Scene LXXXVII., which exhibits the constellations of the southern hemisphere.

Scene No. XLIV.—Libra.

The constellation Libra, is the seventh of the zodiac. It is represented under the form of a pair of scales. The stars are not numerous, but conveniently trace the subject.

Scene No. XLV.—Scorpio.

This is the eighth constellation of the zodiac. It is of considerable brilliancy, and is represented by the figure of a Scorpion, with the usual jointed tail and body, and its two pair of forceps. It looks towards Libra.

Scene No. XLVI.—Sagittarius.

This is the ninth constellation of the zodiac. It is represented under the figure of an animal, half man and half horse, armed with a bow and arrow, the bow drawn, the arrow ready to be discharged. The head of the figure is directed towards the tail of Scorpio.

Scene No. XLVII.—Capricornus.

The tenth of the zodiacal constellations is Capricornus; it follows Sagittarius, and bears the figure of a nondescript animal, having the head, shoulders, and fore-legs of a goat, with the hinder body and tail of a fish; it appears in an attitude of rest, looking towards Sagittarius, and nearly touching it.

Scene No. XLVIII.—Aquarius.

This is the eleventh constellation in the order of the zodiac, and follows very closely upon Capricornus; it bears the figure of a man who carries a vase of water. A line drawn from the upper pointer of Ursa Major, through the chair of Cassiopeia, leads to it: this constellation is so close to Capricornus, that the tail of the latter nearly joins its body.

Scene No. XLIX.—Pisces.

The constellation Pisces is the twelfth of the zodiac, and is situated directly below Andromeda and Pegasus. The figure is that of two fishes attached by a long line, or band, which is irregularly twisted to and fro, to cover, or mark, the irregular lines of stars composing that part of the figure. One of the fish is placed on the south side, the other on the eastern side of the four principal stars of Pegasus.

Scene No. L.—Monoceros and Canis Minor.

Monoceros occupies a large space in the heavens, but has few stars of lustre or magnitude. It forms the figure of a unicorn, and stands immediately below the constellation Gemini; its head nearly touching the feet of the figures in Gemini. Immediately over the shoulders of Monoceros stands Canis Minor; this figure is that of a small dog; its extent is trifling, but it is of important appearance, from containing one brilliant star of the first magnitude.

Scene No. LI.—Canis Major.

This constellation is remarkable, as well from its relative position, in regard to other brilliant constellations, as from its containing the largest fixed star in appearance, and which is, therefore, supposed to be the nearest to our system, namely, Sirius, vulgarly called the Dog-star. The figure of Canis Major is that of a dog, sitting in the posture in which we make a spaniel beg. The animal looks towards Orion, and Sirius marks its mouth.

Scene No. LII.—Orion.

This constellation is of great extent, and is the most brilliant in the heavens. It is situated directly against the front of the bull's head, and somewhat lower, or more to the southward. Its general appearance may be described as that of a rectangular figure, the direction of whose length points towards the pole. If two diagonals be drawn across this rectangle, two principal stars will be found to occupy the two extremities of each: two of these mark the shoulders of the figure, which represents a man in an attitude of fighting; one of the others marks his left foot. At the middle of the rectangle, three bright stars designate the girdle, or belt, of the figure; and from these runs a small train of stars, marking his sword: a shield, or the skin of a lion, is represented, by a line of stars, as being held up by one hand, the other brandishes a club. This portion of the heavens is by far the most splendid of the whole expanse; and the constellation Orion is pre-eminent in its appearance, from the felicitous disposition of the stars that compose it. A line drawn through the belt of Orion, passing through the back of that figure, and continued about twenty degrees, crosses Sirius, which can always be distinguishable by its size and brilliancy, and its contiguity to this constellation.

Scene No. LIII.—Cetus.

Cetus is a constellation of much greater extent than any other in the heavens, but contains fewer stars in proportion to that extent. The head of the animal lies immediately under the feet of Aries. A line drawn from the girdle of Andromeda through the two principal stars of Aries, and continued in the same direction, passes through the largest star in the constellation, in the head of the figure. The animal, although generally called a whale, is represented as a nondescript; its head, neck, and shoulders, are those of a quadruped; from the anterior part of the body project two short legs, with webbed feet; the rest of the body tapers gradually, and terminates in a broad tail.

In speaking of the zodiac, it was explained that the ecliptic is the apparent path of the sun, as seen from the earth, and the real path of the earth, as seen from the sun; both these are, in fact, the same thing; and the ecliptic, being but an imaginary circle, may be transferred in imagination, or extended inwards towards the earth, until it reaches its surface, on which it may be supposed to be drawn. We find it thus marked on the common terrestrial globes.

We shall now shew the reason for placing the ecliptic upon the globe, in the position in which it is drawn.

The axis of the earth *declines from* the upright, or perpendicular, in reference to its own orbit round the sun, about twenty-three degrees and a half; and *constantly declines at that angle in every part of its orbit.* It is, therefore, called the *earth's declination.* It is the same thing to say, that it forms an angle with the plane of the ecliptic, or the orbit of the earth, of sixty-six degrees and a half; these two sums together amounting to ninety degrees; the number of degrees in a quarter of a circle, or the angular space between the plane of the ecliptic, and the top of the earth. Hence that plane divides the earth into two equal parts, in a direction which, in regard to the poles, is *oblique;* being, where it is nearest to them, sixty-six degrees and a half from each, on the opposite sides of the globe. And, as the sun lies directly opposite to those parts of the globe over which the ecliptic is drawn, at some time, in the course of every year, it is said to be vertical to those places; for it then shines directly on the heads of the inhabitants, who, therefore, cast no shadows from the sun, at their mid-day or noon. To be fully satisfied of this, it is only necessary to repeat the very pretty experiment of carrying a small globe round a lamp, representing the sun, taking care to incline the axis properly (about twenty-three degrees and a half from the perpendicular) and making the pole, point always in the same direction.

Now, as particular parts of the earth are always opposite to the sun at certain times of the year, by imagining the ecliptic circle on the globe to be marked with the proper constellations, and divided into degrees, &c., opposite to their corresponding place in the heavens, we are able to ascertain when the sun will be directly opposite to, or vertical at, any given place; which without the assistance of this circle could not be done. The ecliptic, then, is one of the great imaginary circles, properly belonging to the starry heavens, but supposed to be represented on the earth, to assist us in explaining the astronomical phenomena in which the earth is concerned.

Another imaginary circle is the equator, and it is so called because it is supposed to pass round the earth, at *an equal distance from each pole*, and to divide the earth into two equal parts, called *the northern and southern hemispheres*. Now, as the ecliptic and equator each divide the earth into two equal parts, but are differently situated in regard to the poles, they must, necessarily, cross each other in two opposite points; and if, as we have already supposed the ecliptic to be, we also suppose the equator, *extended by a continuous plane to the heavens*, and there imagine it to be described as well as the ecliptic, these planes would cross each other *there*, also, in two opposite points. But the circle on the heavens, *corresponding to the equator on the earth*, is not *there* called the equator, but the EQUINOCTIAL.

The term, equinoctial, is derived from two Latin words, signifying *equal night*, and is given to this circle in the heavens for the following reason:—The earth, in moving round the sun, must be twice in the year precisely at an equal distance between the two places at which the ecliptic and the equinoctial circles cross each other in the heavens, and *only* twice in the year; and then the sun shines precisely upon, or is vertical to, or directly over, the equator; this happens from the axis of the earth being constantly in one position, because it points always to the same star (the pole star). The sun, at all other times of the year, is vertical to, or directly over, places *above* or *below* the equator; that is, further north, or further south. When directly over those places at which the ecliptic crosses the equator, in other words, when the centre of the sun is immediately opposite to the centre of the earth, its light spreads equally towards each pole, and there is, consequently, *equal day and night all over the earth*: the equinoxes then happen; and, as this position of the sun and earth takes place twice in each revolution of the earth, two equinoxes occur in each year; one, taking place in the spring, is called the *vernal equinox*, the other, occurring in autumn, is called the *autumnal equinox*.

It has been explained that the zodiac is a belt, of about sixteen degrees in breadth, appearing to surround the starry heavens; that the ecliptic circle passes along the middle of it; and that the equinoctial circle crosses and intersects this ecliptic circle at two opposite places; these are nearly those points of the heavens in which we observe the beginning of the constellation Aries, on one side, and the beginning of the constellation Libra on the other and opposite side.

The sun is seen from the earth, in the beginning of the constellation Aries, on the 20th of March. This is the vernal equinox. On the 21st of June, the sun is seen in the beginning of the constellation Cancer; on the 23rd of September, it is seen in the beginning of Libra (this is the autumnal equinox); and on the 21st of December, it is seen in the beginning of Capricornus.

It will be recollected that it is the motion of the earth which causes us to suppose that *the sun* moves through the ecliptic; and, of course, that, in thus describing its motion, we only speak according to appearances. But if, instead of describing what is merely *apparent*, we were to describe the *real fact*, we should, instead of saying that *the sun, as seen from the earth* on the 20th of March, is in the beginning of the constellation Aries, say that *the earth, as seen from the sun*, is then in the beginning of the opposite constellation, which is Libra; that on the 21st of June, the earth is in the commencement of the constellation Capricornus; on the 23rd of September, in the commencement of Aries; and on the 21st of December, in the commencement of Cancer. But it is customary, in astronomical considerations, as well as more convenient, to explain that which is apparent rather than that which is real: the sun's *apparent* path is, therefore, described, instead of the earth's *real* path; and hence the sun is said *to move in the order of the signs*, or the order in which the constellations of the zodiac are arranged; appearing, on the 20th of March, in the first of Aries; on the 21st of June, in the first of Cancer; on the 23rd of September, in the first of Libra; and on the 21st of December, in the first of Capricornus.

The sun being, on the 20th of March (the vernal equinox), in the first of Aries, seems, by the 21st of June, to have advanced to the first of Cancer, being that point of the ecliptic which is its greatest apparent height above the equator, *viz.* twenty-three degrees and a half; and as we live on the northern hemisphere of the earth, and the sun is then opposite to certain parts of the earth which are north of the equator, the sun is, at noon, at the highest altitude it ever attains with us, and we have our longest day. Passing through the constellations Cancer, Leo, and Virgo, southwards, the sun appears to have less elevation; it is lower at noon than before; our days become shorter, the sun's warming influence decreases, and, when it appears to enter the constellation Libra, on the 23rd of September, the day and night are again equal; the sun is at the equinoctial; the autumnal equinox takes place. Still descending, travelling onwards through Libra, Scorpio, and Sagittarius, it appears to enter the constellation Capricornus, on the 21st of December; when, being at its greatest distance, twenty-three degrees and a half below the equator, its altitude in the south, at mid-day, is the least we ever have it, and we have our shortest day: appearing to rise from that time, the sun travels through the constellations Capricornus, Aquarius, and Pisces; and, on the 20th of March, again seems to us to enter the constellation Aries: it then again appears in the equinoctial, and we have another equal day and night.

Let me repeat, that all these appearances are owing, not to any real motion of the sun, but to the earth's *actual* motion round it, and to the fact of its axis declining from the perpendicular about twenty-three degrees and a half. The experiment of carrying the little globe round a lamp will assure us of this fact, and we shall then, also, see that, from this declination of the earth's axis, the north polar regions are illuminated by the sun during six months together, and the south polar regions during the other six months.

Between the 20th of March and the 23rd of September the sun appears to us to move through the constellations Aries, Taurus, Gemini, Cancer, Leo, and Virgo; these constellations are, therefore, called the *summer signs* of the zodiac; and as, between the 23rd of September and the 20th of March, it appears to move through the other six constellations, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, and Pisces, these are, on that account, called the *winter signs* of the zodiac.

To Observe the Stars by Day or Night.

Let the observer place himself directly facing the south at mid-day, he has then the north point directly behind him; on his right hand, the west; and on his left, the east. Now we are already informed that the stars appear to rise in the east, to pass over the south, and so proceed towards the west, where they set, or disappear, to rise, or appear again, in the east, after an interval of twenty-four hours from their last appearance in that part of the heavens; and these appearances, we know, arise simply from the daily motion of the earth in the contrary direction. When a star has risen in the east, it continues to attain a higher elevation during its progress towards the south, until it arrives at the south point; it is then at its greatest elevation, and is said to be *on the meridian.* The term meridian, signifies *mid-day.* From this point the star begins to descend towards the west; and so of all the rest. If this observation be made on the 21st of March, which is the time of the vernal equinox, we shall then have the sun before us; and, if the superior brightness of the sun's light did not overpower all other appearances, we should also see a portion of the constellation Pegasus; and, at a higher elevation, nearly over our heads, we should see the constellation Cassiopeia. In an astronomical observatory, a powerful telescope is used for this purpose, which, from its application, is called a *meridian telescope.* In the terms of the zodiac, the sun is, at that time, in the constellation Pisces. Two hours after noon, the constellation Pisces has passed towards the west, and the constellation Aries, which before lay on the eastern side, has now advanced to the meridian. Near to Aries, and towards the north, Andromeda is seen; towards the west, one of the fishes of the constellation Pisces; and to the south, Cetus. At four o'clock, Taurus is on the meridian, preceded by the Pleiades. To the southward of Taurus is seen Orion; to the northward of Orion, Auriga; near six o'clock, Gemini is on the meridian; at about eight, Cancer. At ten, the brilliant constellation Leo comes to the meridian; Leo Minor lies towards the north, separating it from Ursa Major. At midnight, Pisces will not be visible, being then below the western horizon; Virgo is, at that time, on the meridian; Coma Berenices lies at a short distance towards the north. At two hours after midnight, Libra is on the meridian. At four o'clock, Scorpio, and, at six, Sagittarius, respectively arrive on the meridian; at eight, Capricornus is on the meridian; at ten, Aquarius; at noon, the constellation Pisces, having passed from west to east below the horizon, has risen in the east, and now again presents itself on the meridian, in the position in which it was seen at noon of the preceding day. The twelve constellations thus arrive in succession on the meridian.

It must be understood that the times stated for these observations are the hours reckoned by the *apparent motion of the stars*, or the earth's diurnal motion as regards the stars: this is called *sidereal time;* and is that by which all astronomical observations are noted, or measured. In common life, time is measured by the *apparent motion of the sun;* or the earth's diurnal motion as regards the sun: this is termed *solar time*. The solar days, through the whole year, differ among themselves by a small quantity, but the average, or *mean* length, is twenty-four hours.

The sidereal day is always uniform, and is four minutes shorter than the solar; it consists of twenty-three hours, fifty-six minutes. Our common clocks and watches are made to measure solar time. Sidereal time is measured by a clock used only in astronomical observations, and called the astronomical clock.

The time of the return of certain stars to the south, or the meridian, is, of course, indicated by the astronomical, not the common clock. By the astronomical clock, the same appearances of the stars take place at the same hours; but by the common, or solar clock, we find a difference of four minutes per day, or about two hours per month. So, if we look to the meridian on the 21st of April, as we did before on the 21st of March, we shall not find the constellation Pisces on the meridian when the sun is there, or at mid-day as before; we shall find it to have advanced thirty degrees towards the west, and the astronomical clock will indicate two hours *after noon*. The constellation Aries will now be on the meridian at mid-day, and the other constellations in the same relative order as before. As an approximate method for finding the appearance of the heavens, we may, therefore, reckon two hours, or thirty degrees, difference per month, counting from the 21st of March. It follows, therefore, that, counting from the 21st of March, by the observation first described, we shall, at noon, on the 21st of each succeeding month, have all the zodiacal constellations on the meridian in succession, beginning with Pisces. As for example: if we wish to know what constellation will be present on the 21st of June, at ten o'clock of the night; from the 21st of March to the 21st of June, are three months; the entire zodiac contains 360 degrees; each of its twelve constellations, therefore, contains thirty degrees, and each month, also, consists of a twelfth part of the entire year; thirty degrees, or one constellation, will, therefore, pass in each month; from March to June are three months; three constellations will pass in that time: the third constellation from Pisces, from the eastward, *viz*. Gemini, will then be on the meridian at mid-day. Now, there being twelve constellations passing before us in each twenty-four hours of time, each constellation occupies two hours in passing. From mid-day to ten o'clock of the night are ten hours, consequently five constellations will have passed over the meridian, towards the west, since mid-day; five constellations from Gemini bring us to Scorpio: Scorpio is, therefore, on the meridian at ten o'clock of the night of June 21st; and so of any other time, or constellation.

Scene No. LIV.—The Sun's Place in the Ecliptic.

This scene illustrates the meaning of the expression of the sun's place in the ecliptic. It has been already explained, that by the ecliptic is meant the imaginary circle in the heavens, in which the sun appears to move as seen from the earth, or the circle in which the earth appears to move as seen from the sun. The zodiac is that portion of the heavens through the middle of which the ecliptic appears to run, and is portioned out into twelve parts, or divisions, each of which is termed a constellation; as Aries, Taurus, Gemini, &c. The sun, as seen from the earth, always appears in the ecliptic, and, consequently, in some one of these constellations. That portion of the zodiac in which the sun appears, is termed its place in the ecliptic, the ecliptic being itself within the limits of the zodiac.

The scene shews the sun in the centre, and the earth in several points of its orbit round it; and beyond it is a circle, representing the constellations of the zodiac in their order. From the lower figure of the earth, the sun is seen in the constellation Cancer; the sun is then said to be in Cancer. In the next following figure, to the right, the sun appears, from the earth, to be in Taurus; from the next above it, in Pisces; from the upper figure of the earth, the sun appears in Sagittarius; and from the next, or left-hand figure, it is seen in Libra. In each of these positions, the earth, as seen from the sun, of course, appears in the opposite constellation. For instance, in the lower figure of the earth, the sun, from our planet, appears in Cancer; but, from the sun, the earth appears in the opposite constellation, Capricornus.

Scene No. LV.—The Apparent Retrograde Motion of the Planets.

This scene illustrates the apparent retrograde movements of the planets Mercury and Venus. The outer circle of the scene is the circle of the zodiac, or stars, among which the apparent paths of those planets seem to be. In the centre is the sun; the circle of small globes, next beyond the sun, represents Mercury in his orbit; on the border of the scene, to the right, is a green globe, representing the earth. Now, if we imagine the balls, representing Mercury, to move round in their orbit, beginning at the point opposite to the earth, and to move from the right towards the left, the lines which are drawn from the earth through the planet at each stage of its progress, and extended as far as the zodiac, will shew to what parts of that circle the observer on the earth refers the planet; or, which is the same thing, in what parts of it the planet appears to be from time to time. At its first position, at A, it appears, by the direction of the line, to be in the constellation Leo; when it has moved on to B, it appears to have moved forward to the next constellation, Cancer; when at C, it appears still to go forward, and to be at the beginning of Gemini; when at D, to have advanced to the end of

Gemini; when at E, it has still gone forward, and is in Taurus; but from this point it appears to retrograde, and apparently moves back again through the same constellations, among which it before seemed to move forward: for when at F, it appears to have moved back to Gemini; at G, it appears to have moved back to Cancer; when at H, it seems still to move back, for it has then nearly reached Leo again, whence it began to move forward in the first instance. When it has again arrived at A, it appears again to be at the beginning of Leo; and when again it advances towards B, its apparent forward motion is repeated. The scale, K L, on the left hand of the scene, assists the eye in tracing the backward and forward movements. The circle of globes, on the outer side of that on which the planet Mercury is placed, represents the planet Venus in her orbit, and, from her situation as regards the earth and sun, she presents the same phenomena.

Scene No. LVI.—The Earth's Shadows.

It is known that every planet, both primary and secondary, receives its light from the sun, and must, therefore, of necessity, cast its shadow towards that side which is opposite to the sun. Such shadows are, of course, merely a privation of light in the space hidden from the sun by the planet, and are always proportionate in their extent to the relative magnitudes of the sun and the planet. If they were both of the same size, the form of the shadow cast by the planet would be that of a cylinder, of the same diameter as the sun; its length unlimited. But we know that the sun is much larger than any of the planets, and, therefore, their shadows must converge to a point.

Such is the condition of the earth. The scene shews the sun and the earth; the sun being much larger than the earth, the shadow of the latter tends to a point. The distance of this point from the earth is calculated to be about three times and a half the distance of the moon from the earth, or 840,000 miles. In addition to this shadow, which may be called the *dark shadow* of the earth, there is a slight shade which surrounds it, and spreads on all sides, being somewhat darker near the centre than at its edges; this not being a perfect shadow, is termed the *penumbra*, from two Latin words, signifying, almost a shadow. If an observer were placed within the dark shadow, the entire body of the sun would be hidden from him; but if he emerged from the dark shadow into the penumbra, he would gradually see more and more of the sun, until he reached its outer edge, where he would see the whole. On these circumstances depend the phenomena called eclipses.

Scene No. LVII.—Eclipse of the Moon.

The term, eclipse, is derived from a Greek word (ekleipo), to be defective, and is, therefore, expressive of a deficiency of light, from the interposition of some body. The interposition of the earth between the moon and the sun, so that the moon is deprived of the sun's light, produces, what is termed, an eclipse of the moon. The sun is so much larger than any planet, that its shadow converges to a point much within the distance of the next nearest planet, so that not one of the primary planets can eclipse another: the shadow cast by any of them, is not of sufficient length to eclipse any other body, except one of its own satellites; and even this can only happen when the sun, the planet, and the satellite, are on a line, or when the satellite is in opposition. As the sun, earth, and our satellite, the moon, are in this position every month, we might imagine that an eclipse of the moon ought to take place as frequently; this, however, does not happen; owing to the moon's orbit being inclined to that of the earth, she is above the earth's orbit, in one-half of her course, and below it in the other. Her orbit, therefore, crosses that of the earth in two opposite points, called her nodes; and it is only when she is in one of those nodes, at the time that she is in a line with the earth and the sun, that she is eclipsed. Now, the points of the moon's nodes are perpetually shifting; and thence it follows, that eclipses of the moon do not occur at regular intervals of time. By long-continued observation, astronomers have determined that, in about nineteen years, the moon is eclipsed twenty-one times, never more than three eclipses ever happening in any one year; in some years none.

An eclipse of the moon arises simply from the moon, in her course round the earth, passing into, and through its shadow; this takes place only when the sun, earth, and moon, are on a line with each other. The moon's eclipses are either partial or total; partial, when only a portion of the moon's body is immersed in the earth's shadow; total, when it is wholly obscured. In the scene, the sun and earth are shewn, with the earth's shadow, through which the moon is seen passing; in the moon's lower figure, she is just entering the shadow; in the upper figure, she is just emerging from it: it is evident that in a position midway between the two she would be wholly immersed.

Scene No. LVIII.—Eclipse of the Moon.

In this scene, the dark spot in the air is an imaginary representation of the earth's shadow, into which the figure of the moon is just entering. The moon is eclipsed in various proportions, and, to measure these, her disc is supposed to be divided into twelve equal parts, called digits. In speaking of an eclipse, it is, therefore, said, that so many digits, so many twelfth-parts, are hidden. When the moon passes through the centre of the earth's shadow, and her eclipse is, therefore, total, its longest duration is about five hours and three-quarters, from her entering the shadow, to her final emersion.

Scene No. LIX.—Eclipse of the Sun.

From what has been said of eclipses of the moon, it must now be well understood that eclipses, either of the sun or the moon, happen in consequence of one of the two opaque bodies, the earth or the moon, being so placed as to prevent the sun's light from falling on the other. The scene represents the sun, with the moon so situated, that it intercepts the sun's light, and prevents its falling on the earth. In general terms, the interposition of the moon between the sun and the earth, produces an eclipse of the sun. The great distinction between an eclipse of the sun, and one of the moon, is, that the latter is visible at the same time from all those parts of the earth where the moon is at the time above the horizon; while an eclipse of the sun can only be seen from particular parts of the earth, at the same time. And, again, the duration of an eclipse of the moon is the same at all places at which it is visible, while an eclipse of the sun begins and ends at different times, for different parts of the earth.

By the scene it will be understood that the dark shadow of the moon falls on the earth, and at that place hides the body of the sun. The spot of shadow thus thrown by the moon, is never more than 180 miles broad; and as this moves over the earth, with the moon's motion, a total eclipse of the sun does not last longer at any one place than about eight minutes; the moon's shadow travelling on the earth, at the rate of about 180 miles an hour. To those parts of the earth which lie within the actual shadow, the sun's eclipse is said to be *total*. Where the earth is situated within the *penumbra*, or slight shadow (shewn on the borders of the dark shadow), the sun's eclipse is *partial*, *i. e.* only a portion of the sun is hidden.

Scene No. LX.—Eclipse of the Sun.

In this scene the sun is represented, as it appears in nature, with the dark body of the moon passing over it. The moon's shadow is supposed to be advancing at the rate of 180 miles an hour, to the place represented in this scene.

Scene No. LXI.—The Progress of an Eclipse.

It has been already said, that, in estimating an eclipse either of the sun or the moon, as regards the quantity of obscuration, or deficiency of light, the diameter of the whole disc is supposed to be divided into twelve parts, which are called digits; of which so many as are obscured are said to express the *quantity*, or extent, of the eclipse. In the scene, the upper range of figures represents the sun in one line, in twelve repetitions, with a second line oblique, the first, shewing the moon's path as she passes over the sun's disc. The first figure to the right, in the upper row, represents the sun's disc complete, with the moon on the point of eclipsing it. In the second figure, the moon covers the sun's disc, one digit; in the third, two digits; in the fourth, three digits; and so on, until twelve digits, being the whole diameter of the sun, are covered. In the second range of these figures, the moon is seen to pursue her path on the oblique line, and the sun to be uncovered one digit at each figure, as far as the twelfth, when its disc is again wholly exposed. In the lower figure of the scene, the moon's shadow is shewn approaching, gradually advancing upon, and, at last, passing over, the sun.

Scene No. LXII.—An Annular Eclipse of the Sun.

As an eclipse of the sun is produced by the moon, in her motion about the earth, passing between the earth and the sun; if the apparent diameters of the sun and the moon were precisely alike, and their distances unchangeable, it would happen that, whenever they were on a line with the earth, there would be a solar eclipse, and the moon's figure would exactly cover, or hide, the sun from our sight. But the apparent diameters of the sun and the moon are not exactly alike; neither is the apparent diameter of either *always the same.* We have already mentioned these diameters, and stated that, as an approximate measure, they are each equal to about half a degree. The sun's apparent diameter is, however, on the average, somewhat *more* than half a degree; that of the moon, somewhat *less;* and the distances of both also periodically alter, and, with the distances, the apparent magnitudes. It happens, from these circumstances, that, at times, when the moon is between the sun and the earth, her apparent diameter is often *less than that of the sun*, so that she cannot entirely hide its disc, but leaves a narrow portion uncovered all round her body. This, having the appearance of a ring, is termed an annular eclipse, from the Latin, *annulus*, a ring. Such is the figure represented in the scene, where the sun is seen, of its usual apparent size, partially covered by the dark body of the moon.

Scene No. LXIII.—The Phenomena of the Seasons. No. 1.

This scene is intended to illustrate those positions of the earth by which the variety of our seasons is produced. Although the alternations of day and night are occasioned by the diurnal rotation of the earth on its axis, yet this motion is not, of itself, sufficient to produce *variety in the length* of the days and nights, and, consequently, the variety of seasons which the earth experiences in the course of its year. For, if the earth moved on its axis, with one of its poles always pointed exactly to the sun, as in the lower figure in the scene, one half the earth would be constantly in the light, and the other half in perpetual darkness, notwithstanding its daily rotation. Again, if the earth had its equator directly pointed to the sun, as in the upper figure of the earth in the scene, then, by its daily rotation, the sun's light would exactly reach both the poles, and all places would be in light and darkness alternately, and for equal portions of time ; the days and nights would be exactly alike, in length, on every part of the earth throughout the year : there would be different seasons at different places on the earth ; but no variety, no *change of seasons, at every place*, as at present.

But if either extremity of the earth's axis, suppose the northern, were inclined towards the sun, so as to make an angle with an imaginary line drawn between the earth and the sun, it would follow that the north pole, and a small distance around it, would remain constantly in the light. At all places in the northern hemisphere where the sun rose and set, the days would be longer than the nights ; at all places on the equator, the days and nights would be of equal length ; while at all places in the southern hemisphere, the nights would be longer than the days. Under this position of the earth, there would be a variety in the lengths of the days and nights at different parts of the earth ; but still no change in their length at any one place, nor any change or variety of season. Every part of the earth would have its own perpetual season, without variation, as in the two first cases.

This last supposition resembles what really takes place in nature with respect to the earth ; its axis is actually inclined twenty-three degrees and a half from a line perpendicular to its orbit, and it constantly retains this inclination during its course round the sun : its axis always pointing in the same direction, or remaining parallel to itself. These simple circumstances alone produce the whole variety of the seasons. For a further illustration of this, we must refer to the following scene:—

Scene No. LXIV.—The Phenomena of the Seasons. No. 2.

In this scene the sun is represented in the centre, surrounded by the earth, which is shewn in four principal points of view, according with its position during the seasons we term spring, summer, autumn, and winter. In each position the poles of the earth are in the same direction as in nature ; and the boundaries of day and night, as regards the poles, are seen in each. On the outer side of the figures of the earth, are the signs of the zodiac, by which we can understand what, in a former scene, was termed the sun's place in the ecliptic (or zodiac), at the four great points of the earth's orbit ; and, of course, through all the intermediate points.

On the 20th of March, which is the spring, or vernal equinox, the sun, as seen from the earth, appears in the first point of Aries, marked with its character ♈ ; on the 21st of June, our summer, the sun is seen from the earth in Cancer, ♋ ; on the 23rd of September, the autumnal equinox, we see the sun in Libra, ♎ ; and on the 21st of December, our mid-winter, the sun is seen in Capricornus, ♑. The ends of the axis, or the poles, of the earth, are seen to point in the same direction through the whole course of the earth's motion, the axis always remaining parallel to itself.

In the summer position, the north pole, and with it the northern hemisphere, on which we live, is turned more *into* the sun's light than in any of the other positions; our days are longer, our nights shorter. In the winter position of the earth, on the opposite side of the scene, the axis, or line of the pole, still parallel to its former direction, is, of course, turned more *away from* the sun's light than in its other positions; and with it our northern hemisphere: we have, therefore, longer nights, and shorter days.

In the upper figure, which is the place of the earth at the spring, or vernal equinox, the 20th of March, the earth's axis being still parallel to its former direction, the sun's light reaches equally to both the poles; all places are in light and darkness alternately, and the days and nights are equal at every part of the earth.

In the opposite position, or autumnal equinox, the 23rd of September, the same position of the earth again produces the same effects; the days and nights are again equal in every place. Thus, then, the combined motions of the earth (the annual and the diurnal), with the constant and unalterable position and direction of its axis, produce the beautiful diversity in the length of our day and night, and, consequently, the changes of our seasons.

Scene No. LXV.—The Sun at Midnight, at the North Cape.

It is evident, from the last scene, that, at the north and south poles, alternately, the sun is not seen at all during a considerable portion of the year, and that, when it is visible in those regions, it is seen at a less elevation in proportion to the distance from the poles. During the six months between the 20th of March and the 23rd of September, the sun *never sets* to the regions surrounding the north pole; while, during the whole of that time, the south pole is in darkness, and, during the same period, it, there, *never rises*. During the other six months of the year, the reverse of this takes place; to the north pole it never rises, to the south pole it never sets. Between the extremes of these times, the sun is seen at different elevations—sometimes skimming round the horizon during the whole twenty-four hours; at other times, a few degrees above it.

The scene represents the sun, as it is seen from the northern cape of Europe, on the coast of Norway, which is situated about eighteen degrees from the pole. The time of the appearance is midnight.

Scene No. LXVI.—The Phenomena of the Tides.

From the earliest ages, observers of natural phenomena perceived an evident coincidence between the periodical changes of the moon, and the occurrence of high-water; and modern observation has determined the fact, that the moon, in her periodical revolution about the earth, is, by her attractive power exerted on its waters, the cause, generally speaking, of our having periodical tides, or the alternate flowing and reflux of our seas and rivers. But the tides are found to depend not on the moon alone, they are also influenced by the sun, the sun having an attraction for the earth as well as the moon. The highest tides are called spring-tides; the lowest, neap-tides. Careful observation proves that there are two spring-tides, and two neap-tides, in the course of each revolution of the moon about the earth. The spring-tide happens, generally, two or three days *after the new and full moon;* the neap-tide, the same time *after her first and last quarter.*

The scene represents the figure of the earth, surrounded by water, with the moon in two positions in her orbit: in the upper figure, which is dark, she is at the *change;* in the lower figure, which is bright, she is at *the full.* The figure of the sun, on the right of the scene, relates to these two positions of the moon. At the upper figure (the change of the moon), the waters of the earth are attracted both by the sun and by the moon; and their joint action, by raising the waters on that side, produces *spring-tide* at that place. The water is, for distinction, coloured darker than the earth. At the full moon (the lower figure), the sun and moon act in opposite directions, and produce the same effect, although in a less degree. If we now disregard the figure of the sun on the right, and consider that on the left, with respect to the earth and the moon, we have a representation of their relative positions at the first and last quarters; and the lesser tide, now seen immediately under, and opposite to the sun, shews the *neap-tide* there. Thus the tide is greatest when the moon is between the earth and sun; not quite so great when she is in opposition; and smallest in the first and third quarters. The figure shews, then, that there are constantly two elevations of the waters, or tides, on opposite sides of the earth; one on the side directly under the sun, the other on the side most removed from it. Now, as the earth revolves on its axis once in each twenty-four hours, all parts of its waters are brought, in daily succession, under both these accumulations, or tides; and thence it is that we have two tides in the space of each day and night.

The times of high and low tide differ at different places, from the local circumstances of the figure of the points of land round which they pass; the different widths of the seas; the various depths of their waters; and the varying sinuosities of the rivers: but it is ascertained that *these differences are periodical in all places.*

Scene No. LXVII.—The Parallax of the Planets.

It will seem paradoxical to assert, that an inhabitant of the earth can never see any object in the heavens in its true place; it is, nevertheless, strictly true, that none of the heavenly bodies appear to us to be where they *really are.* In the left-hand figure of the scene, we have a representation of the earth, and above it of the moon; if an observer be placed at the end of each of the lines drawn through the moon to the earth's surface, each will imagine the moon to be exactly in the direction of the line along which he views it; and if these lines be continued beyond the moon to the outer circle, which we may imagine to represent the heavens, the difference of the two appearances becomes evident—the observer on the right sees the moon in the *red* figure; the observer on the left sees her in the *blue* figure. It is evident that the true place, as regards the *centre of the earth*, is in the middle position, exactly between the two. The angular quantity contained between the two lines, and coloured *green*, is called the *parallax* of these observations. The word *parallax* means, by its derivation, *difference*, *discrepancy*. The parallax of the sun, moon, or any planet, is the angular difference between its true and apparent place in the heavens; the true place is that in which it would appear from the centre of the earth; the apparent place, that in which it appears from its surface.

The right-hand figure of the scene will explain this. If an observer on the upper part of the earth in that figure, notice the moon in his horizon (in the inner circle, which represents the moon in her orbit), he will see her in the outer circle, which represents the heavens, in the figure coloured *red:* but if he were placed at the *centre of the earth*, the lines shew that he would see the moon in the heavens in the figure coloured *blue*. The angular quantity contained between these two lines, and coloured *green*, expresses the *parallax*.

The nearer the object is to the horizon, the greater is its parallax; the nearer it is to the zenith, the smaller. In the horizon it is greatest of all; in the zenith it is nothing. It will be seen that, in the second, third, and fourth positions of the moon, in the figure, the angle of the parallax becomes less and less, until at the last position, or that directly over the observer's head;—in *his* zenith it is nothing, she appears without any parallax; and her place is the same, seen from the earth's surface, as from its centre.

Scene No. LXVIII.—The Transit of Venus over the Sun's Disc.

The orbits of Mercury and Venus being within that of the earth, those planets are sometimes seen to pass over the sun's disc, appearing like a dark spot. Transits of Mercury have been observed nineteen times; of Venus but three times. Another transit of the planet Venus will not take place till 1874. The general appearance of this phenomenon is shewn in the scene.

Scene No. LXIX.—The Eclipse of Jupiter's Satellites.

It has been already explained that the four satellites of the planet Jupiter are frequently eclipsed to us, by passing through the shadow cast by the planet from the sun's light. The scene is intended to illustrate this subject. The planet, with its satellites in their respective orbits, is shewn, illuminated by the sun, from the right-hand upper corner of the picture. In the lower corner, on the same side, is seen the earth; lines drawn from the body of the planet, and from each satellite to the earth, shew the directions in which an observer sees them. The planet's shadow is thrown, as in nature, in the direction opposite to the sun. The first, or nearest satellite, is seen entering the shadow; to the observer on the earth, it is eclipsed; the second satellite is passing behind the body of the planet, and is, therefore, invisible from the earth; the third has just emerged from the planet's shadow, and is seen on its left; the fourth is seen at a greater distance from the planet, and on the right of it. When the satellites pass through that portion of their orbits nearest the sun, we sometimes see *their* shadows passing over the body of the planet. The application of our knowledge of these satellites and their motions, to important purposes of science, has been already mentioned, when describing the planet itself.

Scene No. LXX.—Comets.

A general account of the nature of comets has been already given. The number of these wanderers, that have been *seen* within the limits of our system, is variously stated at from 350 to 500. The probable number *existing*, in the opinion of the most scientific men of the age, amounts to more than *seven millions!* The orbits of about 100 comets have been determined; of these *three* have known periods of return, and may, therefore, be said to form part of our system. The first is called Halley's comet, of which the period of revolution is about seventy-eight years; the second, Encke's comet, whose period of revolution is about three years and four months; the third is that called Biela's comet, whose revolution is made in about six years and three quarters. This is the comet which it was seriously predicted would, in 1832, its period of return, come into collision with the earth.

The scene gives representations of two comets of the most remarkable appearance: the upper figure is the great comet of 1680; it passed round the sun at a distance of only 147,000 miles, moving at the rate of 880,000 miles an hour. At that time the tail of the comet, of the form shewn in the scene, was sixty millions of miles in length, and became gradually extended till it attained a length of 120 millions of miles. On its near approach to the sun, the sun's body, if viewed from the comet, would have nearly covered the whole extent of the heavens from the horizon to the zenith; and as this comet is presumed to have a period of 575 years, the sun would, at its remotest distance, appear little larger than one of the fixed stars to us. As the tail of this comet extended over ninety degrees of space, when its head had set below the horizon, the tail still reached the zenith.

The lower figure of the scene is a representation of the remarkable comet of 1811. The tail of this comet consisted of two diverging beams of light, faintly coloured; they were both curved a little on the outward sides, and the included space between them was comparatively obscure. The greatest apparent length of the tail was nearly 132 millions of miles; the period of its revolution has been computed at no less than 2000 years.

Scene No. LXXI.—Cometary Motion.

This scene illustrates the nature of cometary motion. It has been already stated, that comets move about the sun in orbits of an elliptical form, of which the longer diameter very greatly exceeds the smaller, having the sun in a point of the figure termed its focus, of which there are two in every ellipsis, lying near to the extremities of the figure. Every comet moves in an orbit of this form; the ellipticity (or difference from a circular figure) varying in nearly every individual case. The rate of motion of a comet, in its orbit, varies with its distance from the sun; inconceivably rapid when at its nearest distance from the sun; and slower as it recedes from him into the remote parts of its orbit. In the scene the sun is shewn on the left of the picture, in one of the foci of the elliptical orbit of a comet; to the right of the sun is the earth in a portion of her orbit. At different points of this elliptical orbit a comet is shewn in its passage, shewing the direction of the tail, in every part of its course, to be opposite to the sun.

In the lower part of this scene the figures explain the different appearances of the tails of comets. The small circular figure, on the right, shews its apparent form when the comet is approaching the observer, or when its length is pointed directly towards him; it is then fore-shortened, and, on the common principles of perspective, appears as in the figure. The small egg-shaped figure, immediately below this, shews the same object when viewed a little obliquely, so that a certain small portion of its length is perceived. The longer figure, above this, shews the appearance when seen yet more obliquely, so that nearly its whole length is visible. The fourth, and longer figure, is the appearance when viewed directly sideways, when the entire length is visible. It will thus appear that the visible character of the tail, to us, depends altogether on the direction in which the comet is presented to the earth.

Scene No. LXXII.—The Laws of Planetary Motion.

In order to comprehend the causes that produce the planetary movements, we must refer to the first simple principles of the laws of motion. All motion is naturally in straight lines. A ball discharged from a cannon, would continue to move in its first direction, if no other power altered its course. If, therefore, we see the ball moving in a curve, we conclude that it is acted upon by two powers; one which has put it in motion, and another drawing it off from the straight course in which it would otherwise have continued to move. As an example, the moon moves round the earth in an orbit nearly circular; the moon, therefore, must be acted upon by two powers: one which would cause her to move in a straight line, another diverting her motion from that line into a curve. An attracting power, competent to do this, must exist in the earth; for there is no other body within the moon's orbit to effect it. The attractive power of the earth, therefore, extends to the moon; and, in combination with her original projectile force, causes her to move round the earth in her curved orbit.

All the planets move round the sun, and obey its power of attraction as their centre of motion; therefore the sun must possess an attracting power as well as the earth. The scene before us shews the sun in the centre, and, about it, a circle representing the earth's orbit, having the earth in one position at A. If we suppose the earth, at its creation, to have been projected forward into space, we know that, if no obstacle impeded its course, it would have proceeded in the same direction, and at the same rate, for ever. Let us suppose the earth to have arrived at the point in which it is represented in the figure, with a rate of motion sufficient to carry it to B, say in the space of one month, while the sun's attraction, if acting alone, would have drawn it to C in the same time: now, according to the laws of motion, the earth would move directly in a straight line to D. But the force of attraction is continually acting upon it, and producing an incessant deviation from a straight line, converting it into a curve. Again, from the point D, it still retains its tendency to fly off in a straight line, and is again acted upon by the sun's attraction, and obliged to take a curvelinear direction as before; and, as the same causes continue to act, the motion in a curve becomes constant, and it completes the circle. The other figures of the earth, on its orbit, shew a repetition of the same effects, which, of course, take place in every part of it; for the causes producing a curved line of motion in one part of the orbit, continue to act through the whole circuit. The outer circle of the scene shews, simply, the circular path, and the straight direction in which the planet would, at any point of its course, fly off, as from A to B, if it were not restrained by the attraction of the sun.

Scene No. LXXIII.—The Moon's Surface: Kepler.

The accurate observation of the moon's surface was one of the earliest applications of the telescope. Its remarkable mountains and cavities, ridges, detached rocks, and annular spots, have been examined and drawn by different observers. From the most interesting of above 200 of these, the following four scenes are selected, to illustrate their general appearance when viewed with telescopes of great magnifying power. The spot, Kepler, the subject of the scene, is remarkable for its brilliancy, and its widely extended and varied ramifications, which consist of vast rocky ridges and hollows alternately, with cavities of great extent and depth; the bright circular spots of this place are considered to be insulated mountains, or peaks, highly illuminated. Kepler is situated on the eastern, or left border of the moon, at the distance of about one-fourth of her diameter from the edge.

Scene No. LXXIV.—The Moon's Surface: Cleomedes.

This is one of the most remarkable and distinctly marked spots of the moon; it is the dark elliptical spot, always visible to the naked eye, on the western border of the disc, or the right border of the moon, as we see it. Through the telescope this vast hollow appears raised in its middle portion, with an immense ridge of rocks stretching across its width, from its upper, or northern margin, to its lower. The borders of this hollow are, on all sides, continuous ridges of rocks.

Scene No. LXXV.—The Moon's Surface: Fracastorius.

This spot is situated on the south-western part of the moon's disc, or on the right side, about one-fourth of her diameter from the lower edge. Its upper portion is a vast hollow; and on its lower, or southern border, are two remarkable cavities of greater depth, and bordered by an annular ridge of high rocks, from which radiates an extensive straight ridge of heights, brightly illuminated; smaller mountain peaks are interspersed; and on the right, or western side, a remarkable elevation is seen, having a high annular ridge surrounding it, and an insulated peak in its centre.

Scene No. LXXVI.—The Moon's Surface: Tycho.

This is the remarkable spot, on the lower part of the moon's disc, which is always distinctly visible to the naked eye, and which seems the centre of those bright radiating lines of spots, which richly cover the south-western, or right-hand lower portion of the moon. Caverns, or hollows, occur most frequently in this quarter; and it is from this circumstance that it is the most brilliant part of the moon's surface. The mountainous ridges, which encircle the cavities, exhibit the greatest quantity of light; and, from their lying in all directions, with an uniform distribution, and yet radiating from the central spot, they seem passages to the vast cavity in which the bright spot is situated. This cavity is estimated to be fifty miles broad, and nearly three miles in depth.

Scene No. LXXVII.—The Constitution of the Moon.

In this scene, two remarkable spots of the moon are selected, to explain the general opinions of the actual condition of the moon's surface. The first figure, to the right, is the middle portion of the spot Kepler; immediately below it is a vertical section, or a cut supposed to be made directly down through the moon's surface, in which, by direct and easy comparison, the bright spots of the moon are shewn to be the elevated peaks of mountains, the darker places to be the spaces between the peaks, and the darkest spots of all the deepest recesses. This is easy to trace, by referring the bright spots to the peaks of the section; the darkest spots to the hollows. The second upper figure, to the left, is a similar view of a portion of the spot Fracastorius; the corresponding figure is its section, as in the first figure.

Scene No. LXXVIII.—The Constitution of the Sun.

This scene illustrates the actual condition of the sun's surface. The upper figure is a small portion of the disc; in which one spot is repeated and traced through several observations, or shewn as it would appear on different parts of the disc; by which it is manifest, that the spherical figure of the sun produces, naturally, a difference in the apparent shape of the spot. The first figure, to the right, shews the spot as it appears when it is seen directly in front; the second, when, being a little removed towards the left, it becomes narrower; the third, still further removed towards the edge, retains its full height, but is diminished in width,—it is sensibly oval; in the fourth, this is more evident; in the fifth, it has become very narrow; in the last, near the edge, it has diminished to a mere stripe of oval form; some parts, which were visible in the other stages, have even altogether disappeared. Herschel supposes the dark spot to be the actual body of the sun, seen through an opening in his luminous clouds, or atmosphere. The bright edge, as it is seen in the third, fourth, and fifth figures, he considers the edge of the luminous clouds. The lower figure, to the left, is an enlarged view of a spot, of which the opposite figure, on the right, is a section through the middle of its length; the perpendicular lines shew the direction in which the observer is supposed to view the sun. The space, A, shews the actual body of the sun, and corresponds with the dark spot in the centre of the large figure; the spaces, C, C, represent the next darkest tint which surrounds the dark central spot; D, D, the bright apparent surface of the sun; and B, the bright edge of its luminous clouds.

Scene No. LXXIX.—The Origin of the Asteroids.

The existence of four planets between the orbits of Mars and Jupiter, revolving about the sun at nearly the same distances, and differing from all the other planets in their diminutive size, and in the position of their orbits, is one of the most singular phenomena in the history of astronomy. The disagreement of these phenomena with the regularity of the planetary distances, and with the general harmony of the system, suggested to astronomers the opinion that these irregularities were produced by some great convulsion; and that the four small planets are the fragments of a larger planet, which once existed between Mars and Jupiter, and circulated round the sun nearly in the orbit of the larger of the four fragments (the planet Pallas). The circumstances of the new planets furnish many direct arguments, all concurring to shew that they have originally diverged from one point of space, and have, therefore, been originally combined in a larger body. It is not difficult to astronomers to ascertain, in general, the consequences that would arise from the bursting of a planet, and to determine, within certain limits, the form and position of the orbits in which the larger fragments would revolve round the sun. Such inquiries have been instituted, and are found to coincide, very accurately, with those facts respecting the planets which are determined by actual observation.

In the scene, we have the sun on the right hand; on the left, the supposed original planet, coloured *red*. In four separate orbits are shewn four fragments, such as may be imagined to result from the disruption of the central planet; each of which, when its explosive, or direct force, is balanced by its gravitation towards the sun, begins to move in an orbit, as seen in the figure, in the case of each of the small spheres coloured *light red*.

Scene No. LXXX.—The Milky Way.

The Milky way is a luminous band, or zone, which appears to make a complete circle in the heavens. In our hemisphere it is seen to traverse the constellations Cassiopeia, Perseus, Auriga, Aries, and part of Gemini. Herschel has determined, from numerous observations, that the brightness of the Milky way is owing, solely, to numerous small stars; and that the closeness of the stars to each other, or what he terms their compression, increases in proportion to the brightness of the Milky way. This phenomenon, therefore, is considered as a very extensive branching stream of many millions of stars, which, probably, owes its origin to several remarkably large, as well as closely scattered small stars, that may have drawn together the rest. It appears, clearly, that the stars of the Milky way are not equally distributed over it, but cluster together in distinct allotments; and as there are many parts which are almost destitute of stars, it is considered that those which may once have filled these vacancies, now form nebulæ, or separate collections.

The upper figure of the scene represents that portion of the Milky way which traverses our hemisphere; the lower figure, a section through its supposed length. Our solar system is supposed to be in the centre; and the longer branches to be the direction of the brightest spots we see; the shorter distances the parts where there are fewest stars.

Scene No. LXXXI.—Clusters of Stars.

In the apparently unequal distribution of the stars, there are many which seem nearly close together, and at equal distances from each other, without possessing any determinate figure. These collections are called *groups of stars*. There are other collections of stars which differ from these in the greater beauty of their arrangement: these clusters are considered the most magnificent objects in the heavens; their form is generally round; and the whole appearance of a *cluster* indicates the existence of *a central power by which they are drawn, or held together*. Herschel found, on examination of such clusters, that the number of stars in each often exceeded 300,000.

In the scene, we have examples of various modes of clustering. The first figure, on the left, is a thinly scattered cluster, of uniform arrangement; in the second figure, a similar cluster is seen, in which the stars towards the centre are drawn more closely together; in the third, two instances in which they are clustered more closely, and in a more determinate form; in the fourth, the clustering takes a determinate figure, and becomes more dense as it approaches the centre; the fifth figure is a space of circular form, which seems to be composed of stars closely clustered together, and placed at an immense distance; the sixth, and last figure, is an instance of an appearance that frequently occurs—a brilliant central point, having a uniformly luminous atmosphere.

Scene No. LXXXII.—Nebulous Stars and Nebulæ.

The appearances, termed nebulæ, seem to be clusters of stars so distant, or so numerous, as to present the effect of a bright or luminous cloud. We have accurate catalogues of several thousands of these phenomena made from actual observation. Of these, the scene gives examples of each variety. The first figure, on the left of the picture, is a close mass of stars, intermixed with a fainter light; it presents the appearance of a solid sphere composed of stars, compressed into one blaze of light, with detached stars surrounding it. The second figure is double; the two parts appear to be composed of stars like the last; they are of different degrees of brightness. The third figure, is an instance of a single small and bright star, having close to it a luminous stripe, or ray. The fourth, is a very bright central figure of an oval form, and surrounded by a space of mottled, or uneven light. The fifth figure is a portion of a larger nebula in the constellation Orion ; it is composed of an extensive mass of stars, having two particularly bright central spots. The sixth, and last figure, is an instance of a small bright star, enveloped in a slightly luminous cloud.

Scene No. LXXXIII.—The Nebula of the Constellation Hercules.

This is a highly magnified view of a remarkable and brilliant nebula in its natural appearance ; it is found in the constellation Hercules. It presents a beautiful appearance, bright in the centre, and surrounded by luminous matter. It was found, by Herschel, to consist wholly of stars.

Scene No. LXXXIV.—The Nebula of the Constellation Andromeda.

This is, also, a highly magnified view of one of the most splendid nebula. It is situated near the middle of the constellation Andromeda. Its figure is a long and narrow ellipsis, having great brightness in the middle of its length, and a lesser degree of brightness at one of the extremities ; it is, also, considerably brighter in one half of its length than in the other ; it has small stars scattered lightly on and about it. This nebula Herschel, also, found to be composed entirely of stars.

Scene No. LXXXV.—The Nebula of the Constellation Orion.

This, also, is a view of one of the most remarkable and brilliant nebulæ. It is situated in the constellation Orion, and may be satisfactorily observed with a telescope of moderate magnifying power ; several small stars are found dispersed over it.

Scene No. LXXXVI.—The Great Nebula of the Solar System.

This scene illustrates the opinion held by Herschel, and subsequent astronomers, on the subject of the Milky way. Herschel accounted for the appearance of the great zone of stars we term the Milky way, by supposing it to be an extensive nebula, entirely surrounding the sun and the whole solar system at an immense distance. This nebula he conceived to consist of a ring, divided, on one of its sides, into two branches, which, when viewed from the earth, would produce the effect we find assumed by the principal stream and the diverging branches of the Milky way. The figure of this scene is, of course, not a telescopic observation, but, simply, a pictorial diagram to explain the extraordinary and interesting opinions held respecting the nature and extent of the phenomenon.

Scene No. LXXXVII.—The Constellations of the Southern Hemisphere.

The constellations which are visible to us from the northern portion of the earth, have been already described under the scene representing the northern hemisphere. The whole number of the stars visible from the earth, on all sides, is arranged in three classes: those that are visible from the northern side of the earth's equator, are called northern constellations, and are spoken of as composing the *northern hemisphere;* those which are situated about the ecliptic, or earth's path, are called the constellations of the zodiac; and those which are visible on the southern side of the earth's equator, are called southern constellations, and are said to compose the *southern hemisphere.* Of these there are forty-five, of which the following are the most remarkable:—

Argo Navis (the Ship)
Crux (the Cross)
Centaurus (the Centaur)
Canis Major * (the Great Dog)
Cetus (the Whale)
Columba (the Dove)
Eridanus (the River)
Grus (the Crane)
Hydra
Indus (the Indian)
Lepus (the Hare)
Lupus (the Wolf)
Pavo (the Peacock)
Phœnix
Piscis Australis (the Southern Fish)
Triangulum Australe (the Southern Triangle).

Scene No. LXXXVIII.—Centaur, Lupus, Crux, Musca Borealis.

The constellations Centaur, Crux, and Lupus, are so close to each other as to form, in fact, but one constellation, although classed separately in all catalogues of the stars. In relative situation this group is close to the constellation Scorpio, and at nearly an equal distance from Libra and Sagittarius. In figure, the Centaur is the known fabulous animal compounded of man and horse. He is in the posture of walking, having, in his right hand, a spear, with which he transfixes the wolf (Lupus); Scorpio is directly before him; the head of the wolf touches the claws of Scorpio; Crux is on the hinder legs of the Centaur; Musca Borealis directly beneath his feet.

Scene No. LXXXIX.—The Constellation Argo Navis.

This constellation is situated directly behind the figure of the Centaur. The figure is that of an ancient ship, with mast and sails. The bottom of the hull comes within a short distance of the south pole, while its mast reaches to the hinder legs of Monoceros on the equator.

* Canis Major, and Cetus, have been described in the northern hemisphere, because periodically visible there.

Scene No. XC.—The Constellations Indus, Pavo, Grus, Toucan.

These constellations are also situated so near to each other that they are included within a space occupied by many other constellations singly. They are directly under the feet of Sagittarius, and mid-way between the constellations Centaur and Pisces. The figure of Indus is, simply, an Indian bearing arrows. Pavo, the peacock, stands directly in front, covering his legs. Grus, the crane, is a large figure of that bird, standing behind Indus; its beak nearly touching the arrows. Toucan is represented by the figure of that bird, in a standing posture, directly below Grus, and in front of Pavo; its beak nearly touching the breast of Pavo, and the right leg of Indus.

Scene No. XCI.—Explanation of Atmospherical Refraction.

This scene illustrates the nature and the properties of what is termed the refraction of our atmosphere. In the practice of astronomy this refraction is of great importance in its effects; for, in consequence of this property in the air, all the heavenly bodies actually appear to us *considerably higher than they really are.* We are, most of us, acquainted with the common experiment in which we place a coin in a basin, so that it is just hidden by the edge of the vessel; we then pour water into the basin, and the coin seems to rise into view: this is in consequence of the refraction, or bending, of the rays of light, which, when they pass out of the water into the air, are, as it were, bent upwards through the water, and the coin seems to rise. Just so are the rays of light refracted, or bent, in passing from the sun, through the atmosphere, to our eyes, though not so greatly, because the refractive power of the atmosphere is less than that of water, on account of its less density. But, in consequence of that power, we usually see the sun, as though it were above the horizon, for about seven minutes after it is really below it—after it has set.

The refractive power of the atmosphere is greatest at the horizon, and diminishes in proportion to its distance from it; so that a star, over head, is seen nearly in its true place, while another, just below the horizon, is seen as though it were above it. The refractive power of the atmosphere is, therefore, always considered, in determining the true place of a star, the sun, or of any other celestial body.

In general, the horizontal refraction is nearly equal to the diameter of the sun or moon; and, therefore, the whole disc of the sun or moon will appear above the horizon, both at rising and setting, although actually below it. In the figure on the right of the scene, the sun, coloured *red,* represents the place of the real sun; the sun, coloured *yellow,* the place of the apparent one: the angle between the two figures is called the angle of refraction. On the left of the scene, a portion of the earth is shewn, with its atmosphere coloured *red;* a planet is represented in four positions round it. At the lowest position, the planet, coloured *red*, is exactly at the horizon; the figure, coloured *yellow*, immediately above it, is the apparent place of that planet. The same planet is again shewn a little higher; the refraction, or difference, between the real and the apparent place, is now rather less than before. It is shewn again in a higher stage of elevation, where the refraction, or difference of the place, is still less. In the last position, where it is in the zenith, the difference is *nothing*—there is no refraction.

Scene No. XCII.—The Horizontal Moon.

This scene exhibits a phenomenon which is of frequent occurrence. When the sun, either at its rising or setting, or the moon, when she is at the full, is near the horizon, it then appears of an elliptical form, with the longer diameter parallel to the horizon. This appearance is occasioned by the refraction of the atmosphere, which, as we have said, is greatest at the horizon, and, consequently, the lower edge is more refracted than the upper edge; and, therefore, these two edges will appear to be brought nearer to each other, and the vertical diameter will appear to be shortened; and, as the horizontal diameter is very little affected by the refraction, the object must assume an elliptical shape.

This phenomenon is more frequently observed of the moon, than of the sun, and it is, therefore, designated as of the moon; although we may, with equal propriety, speak of it in connection with the sun.

Scene No. XCIII.—Atmospheric Refraction.

The refraction of the atmosphere frequently produces very curious and surprising effects on terrestrial objects. It sometimes happens that a stratum of the earth's atmosphere, next to the earth, is accidentally expanded, or condensed, by which distant objects, instead of being elevated, are depressed; and sometimes, from two such strata of different densities being placed together, the objects are elevated by one of them, and depressed by the other, and they appear double; one of the images being *direct*, and the other *inverted*. The scene exhibits two curious varieties of this phenomenon. In the first figure, to the right of the picture, the hull of a ship is seen with its masts and rigging; it is in the horizon, and is the actual vessel. Immediately above it, and joining it by its most elevated part, is seen *an inverted image* of the vessel, perfectly distinct and visible in its most minute detail; as the ship moves, the inverted image is found to advance with it without change: this is a case of one refracted image. The next is a case of a double refracted image. On the left of the picture, *the topmasts alone* of a vessel are seen above the horizon; at some distance in the air, above this, are seen two complete images of *the entire ship*, one being *direct*, the other *inverted*, the two images being joined together by the line which the water made on the hull. As the real vessel recedes from the observer, the two images, still joined, descend towards the horizon.

Scene No. XCIV.—The Aurora Borealis.

The aurora borealis, or northern light, is a luminous electrical meteor, frequently seen in the northern part of the heavens, but sometimes in the southern. Its most usual appearance, at first, is that of a strong white light, which spreads over the northern quarter of the heavens, and rapidly assumes a pyramidal form, with frequent shooting columns of light on all sides, but chiefly towards the zenith. These columns subside and reappear, without regularity of form or arrangement, and, frequently, after spreading over the entire expanse of the heavens, change into a splendid display of variegated colours. The simple phenomenon is often seen in England at all seasons; the more splendid and variegated exhibition is seldom observed here, but in the high northern latitudes it is of common occurrence. The colours of the simple aurora consist of all the varieties of red, from the most delicate rose-colour to a full scarlet; and from a white light to the richest golden tints. In the arctic regions the colours are of infinite variety; the richest red, blue, yellow, green, violet, and every imaginable shade of these, distinct, or in combination. In those latitudes the phenomenon is, also, accompanied by audible rushing and crackling sounds, resembling those of a vivid fire.

Scene No. XCV.—Parhelia. No. 1.

Another singular and beautiful phenomenon, sometimes seen in the heavens, and which is connected with the refractive property of the earth's atmosphere, is an image of the sun in the close vicinity to the sun itself: it has, therefore, the name of Parhelion, from two Greek words, meaning *near to*, and *the sun*. The image sometimes appears above the real sun, at other times below it; but it is more frequently seen to the right or left of the sun, and at the same height. Parhelia are sometimes single, at others double; even three have been seen. Two of the most extraordinary and brilliant are selected for illustration in the present scene.

In 1698, the appearance here depicted was seen in England. Beneath a dark and watery cloud in the east, the real sun shone out with its usual brightness, as the centre sun of the three shewn in the scene; on each side, at the distance of about one diameter and a half of the real sun, a false sun appeared, of nearly equal brilliancy, and perfectly white. At the same time, towards the south, and at a considerable distance from the sun, a figure of a *half sun*, having its convex side towards the real sun, and of more than double the diameter of the sun itself, was seen. The half sun was of a vivid rose colour, approaching to scarlet. The phenomenon was observed at eight o'clock in the morning; it remained fully coloured and distinct for a considerable time, and, fading gradually, disappeared in about two hours.

Scene No. XCVI.—Parhelia and Halos. No. 2.

A halo is an extensive luminous ring, which is frequently seen to surround the sun or moon. This phenomenon is most frequent about the moon, and it occurs whenever she is seen through an atmosphere unusually charged with moisture, or is indistinctly observed through thin strata of clouds. It sometimes happens that we have the halo and the parhelion exhibited at the same time; in this case it is, of course, a halo of the sun. An instance of this is shewn in the scene, in which these phenomena are combined with a third optical phenomenon—the rainbow. In the year 1721, a broad and bright halo was seen about the sun, and, on either side of the sun, a bright and distinct false sun appeared on the halo, at the extremities of its horizontal diameter. Above the halo, and about half way towards the zenith, was the arc of a rainbow, in an inverted position, the convex side towards the sun; the red colour of the rainbow was on its convex edge; the blue, on the concave side; the real sun was of its usual colour and brightness; the false suns were pink on the sides nearest to the true sun, and white on the opposite sides. The halo was also of a bright pink colour on the edge nearest the sun, and white on the outer edge. The rainbow was as perfect and bright in its colours, as usual, and of the ordinary breadth. The phenomenon was repeated on the following day, and again in a few days after.

Scene No. XCVII.—The Zodiacal Light.

Another luminous phenomenon is frequently seen in the heavens, which, although not of the same brilliant and decided character as those we have just considered, is interesting and of great beauty. It is called the zodiacal light, because it is seen only in the direction of the zodiac. Its figure resembles an inverted cone, having its base towards the sun, and its axis lying along the zodiac, a little inclined towards the horizon. Its length from the sun, which is situated in its base, to its vertex, varies from about forty-five degrees to 120 degrees. It is most favourably seen in the earliest days of March, a short time before sun-rise, or after sun-set. It is variable in its colour, according to the state of the atmosphere; but is generally of a pure and delicate rose tint. It has been conjectured that the zodiacal light is really a luminous atmosphere of the sun, and that it derives the figure of a long and narrow ellipsis (of which we see sometimes less than one half), from its rapid revolution, with the sun, on its axis. The most eminent astronomers of the age, however, differ in their opinions as to its cause; some of them think that the only probable means by which the zodiacal light could assume, or retain its figure, would be by means of a revolution much more rapid than that of the sun's rotation on its axis.

Scene No. XCVIII.—Clouds—Cirrus.

Clouds are generally supposed to be formed of invisible vapours, which are raised from the sea and land by heat; and which, ascending until they arrive at a part of the atmosphere of the same specific gravity with themselves, there combine with each other, become more dense and opaque, and, ultimately, visible. The thinner the clouds are, the higher they rise in the air; it seldom happens, however, that their height exceeds two miles. The greater number of clouds do not rise above one mile in height; thunder clouds are seldom higher than half a mile. The study of the characters of the clouds being important to the science of astronomy, in as far as they are closely connected with the earth, a few scenes are devoted to the explanation of the different varieties, and their dependance on each other. The present scene shews the simplest form; *cirrus;* clouds of this character have the least density, the greatest elevation, and the greatest variety of extent and direction. They are the earliest appearances after serene weather.

Scene No. XCIX.—Clouds—Cirro-Cumulus.

The cirrus cloud having continued for some time increasing, or stationary, usually passes into the form of the *cirro-cumulus.* This is represented in the scene. When the cirro-cumulus is thus formed, it descends to a lower station in the atmosphere. This modification produces a very beautiful sky, frequently exhibiting several distinct beds of small connected clouds, floating at different altitudes. The cirro-cumulus is frequent in summer, and in warm and dry weather.

Scene No. C.—Clouds—Cirro-Stratus.

This cloud results from the fibres, or threads, as it were, of the cirrus, subsiding to an horizontal position, and, at the same time, drawing closer to each other. This form of cloud precedes wind and rain; it is generally to be seen during the intervals of storms. The cirro-cumulus is the cloud which most frequently exhibits the phenomena of the solar and lunar halo, and the parhelion; hence the prognostic of foul weather, which is commonly drawn from the appearance of the halo.

Scene No. CI.—Clouds—Stratus.

This cloud may properly be considered the cloud of night, the time of its first appearance being about sun-set. It comprehends all those spreading mists which, on calm evenings, ascend in sheets from the bottom of valleys, and the surface of water. Its duration is frequently throughout the night. On the return of the sun its hitherto level surface appears suddenly accumulated into heaped portions, and separates from the earth; its continuity is next destroyed, and the cloud ascends and evaporates. It has always been considered a prognostic of fair weather.

Scene No. CII.—Clouds—Cumulus.

This modification of cloud is the most dense of any; it is formed in the lower parts of the atmosphere, and moves with the current of wind which is nearest to the earth. A small irregular spot first appears, and becomes, as it were, the nucleus or foundation upon which the cloud is formed. The lower surface continues irregularly plane, while the upper structure rises gradually into conical or hemispherical heaps, which, afterwards, continue nearly of the same bulk, or rapidly rise to mountainous masses, as represented in the scene. In the former case they are usually numerous and near to each other; in the latter, they are few and distant; but, in both cases, their bases always lie nearly in one horizontal plane, and their increase upwards is generally proportionate to the extent of their base, and nearly alike in those clouds which appear at the same time.

In fair weather these clouds are periodical in their appearance; they usually begin to form a few hours after sun-rise, arrive at their greatest bulk in the hottest part of the afternoon, and, after that time, begin to diminish, and wholly disperse about sun-set. When the cumulus does not subside at sun-set, but assumes a more vast and mountainous character, it indicates a highly electrical state of the atmosphere and clouds, and is generally followed by lightning.

Scene No. CIII.—Clouds—Nimbus, or Rain-Cloud.

Clouds, under any of the preceding modifications, often increase so as completely to obscure the sky, and put on an appearance of density, which, to an inexperienced observer, indicates rain. It is seldom, however, that these clouds, in any of the states described, do produce rain; for, before this effect takes place, they undergo a change, forming a new modification, represented in the scene, and called the nimbus, or rain-cloud, with reference to its immediate effects. The nimbus, although in itself one of the least beautiful of clouds, is yet frequently accompanied by that most splendid of all celestial phenomena—the rainbow.

Scene No. CIV.—The Rainbow.

The rainbow is of more frequent appearance than any other of those beautiful phenomena which may be termed uncertain, or irregular. It is only seen during rain, and in that point of the heavens which is opposite to the sun; being produced by an optical effect of the sun's light on the drops of rain as they descend. The property, in a glass prism, of producing seven distinct colours, by separating a colourless ray of light into its component parts, is well known; this division of a ray of white light into different colours being caused by the different angles of refraction of the various coloured rays. The rainbow exhibits a series of colours similar to those seen in the experiment with the prism, and by the operation of the same cause; namely, the unequal refraction of the rays of light in their passage through a shower of rain, every separate drop of which acts as a little prism, in separating the coloured rays as they pass through it, and afterwards exhibiting them in their separated state.

All rainbows are portions of circles, and the eye of the observer is always opposite to the centre of the circle. The quantity of the circle seen, depends on the height of the sun above the horizon at the time; for, as the eye of the observer is always directly between the sun and the centre of the circle, of which the rainbow forms a part, if the sun be high above the horizon, a line drawn from the sun through the observer's eye, and so forward, would pass below the visible horizon on the opposite side, and he would see a rainbow of only a small portion of a circle, as in the lowest figure of the scene; where, it is evident, the centre of the circle is below the horizon. If the sun be in the horizon, then a line drawn, as before, through the eye of the observer, would exactly cut the opposite horizon, and he would see a rainbow exactly equal to a semicircle, as in the upper figure of the scene. The bow represented on the right of the picture, has its centre in a line with the eye of the observer and the sun; which must always be the case: but, in this instance, the bow appears in a different situation to the others, simply because the sun, which produces it, is situated farther to the left.

The centre of every rainbow, then, is to be found in the continuation of a line drawn through the eye of the observer and the centre of the sun; and, therefore, the appearance of every rainbow requires the circumstance of *falling rain in the direction of that line.*

The phenomenon of the prismatic colours, as in the rainbow, is sometimes seen in *a complete circle;* but this rarely occurs, and then generally in mountainous countries.

The light of *the moon* sometimes produces a rainbow, in which all the colours are distinctly exhibited, and the figure of the arc is perfect; the *lunar rainbow* differing from the *solar* only in its subdued brilliancy.

In accordance with the plan of this descriptive Lecture, we have now completed our survey of the heavens, and made as close an examination of the several phenomena, of their mutual dependance and action, their respective peculiarities, and of the laws by which they are governed, as will afford a distinct comprehension of the whole, with as much detailed information as could be readily conveyed in familiar language, and within the necessary limits of a treatise of this character.

In this rapid and general view of the subject, the dimensions, distances, and velocities of the bodies described, are spoken of with as much confidence as though it were possible to determine them with the same facility as we ascertain the distance of one place from another on the earth. But, as may be easily imagined, the distinct knowledge of these points has been the work of successive ages, and has been obtained by the laborious exercise of the highest powers with which the human mind is gifted. To ascertain with clearness, and any degree of accuracy, the *apparent* motions of the heavenly bodies, was a task of great difficulty to the earliest observers. To demonstrate the *real* motions, demanded the patient perseverance, the judgment, and dexterity of men naturally gifted, and profoundly learned; but to arrive at a knowledge of the *laws* of these motions, required a combination of circumstances, and the exertions of sagacity, scarcely to be expected from man's faculties; and it has been with the distances and dimensions of these bodies, as with their motions. Yet all this has been accomplished; distances, dimensions, and velocities, have been ascertained; and the most minute movements of the heavenly bodies have been shewn to depend upon *one general law*, which regulates and governs the whole.

To prove these astonishing facts fully, it would be necessary to follow the mathematician in his illustrations, which cannot, in this place, be attempted. We have here to do only with the *result;* we take advantage of what the astronomer has done. We gather delightful information, without entering into profound detail, and without attempting to proceed to the depths of a science, the limits of which are, to us, immeasurable.

It is impossible to rise from the contemplation of such scenes as are opened to us by Astronomy, without a strong sense of the dignity and high interest of the subject. The most superficial observer comprehends that the object of the science is the study of the laws of a *Divine administration*.

The consideration of what passes daily in nature, prepares us to receive the great truths of Astronomy; but the first general acquaintance with the facts of the science, satisfies a reflecting mind that its principles are of a nature too vast for human comprehension. We are called upon to consider *millions of miles*, in distances, magnitudes, and velocities; to think of bodies floating in space millions of miles distant from us; of velocities thousands of times greater than the swiftest motion that human art can produce; of endless, boundless space, in which *millions of millions* of miles are but as points in comparison; of periods of time, too distant from the present for us to conceive; of a never-ending, an eternal duration.

The natural progress of astronomical study is as truly delightful as its effects are beneficial and ennobling. The immeasurable character of the universe becomes evident to us on the first inquiry; the attention is next engaged by the beautiful order of the arrangement, and the regularity of the movements, everywhere established; and to this succeeds a conviction, that the harmonious operation of the whole is effected under the unalterable government of general laws emanating from a Divine intelligence.

"*In no part of the creation has the Almighty left himself without a witness; but it is in the heavens above that the Divine attributes are most gloriously displayed.*"

Impressed with a due sense of the importance of the subject, and an unaffected humility as regards his endeavour to aid its promulgation, the author concludes, as he began, with those indescribably grand and most impressive words which dignify his title-page:

"IN THE BEGINNING, GOD MADE THE HEAVEN, AND THE EARTH."

FINIS.

Whitehead & Co., Printers, 76, Fleet Street, London.