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RUDIMENTS

OF

ASTRONOMY:

CONTAINING

A DESCRIPTION OF THE GLOBES OF THE SOLAR SYSTEM, AND A TABLE OF THE LONGITUDE OF THE PLANETS AND MOON, ON

EVERY DAY OF THE YEAR 1849;

WITH

DIRECTIONS FOR USING THE DIAGRAM OF THE SOLAR SYSTEM, SO AS TO REPRESENT THE RELATIVE POSITIONS OF ALL THE HEAVENLY BODIES EVERY DAY.

BY ENOS STEVENS.

BOSTON:
PUBLISHED BY JAMES FRENCH, 78 WASHINGTON STREET.
1849.

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BOSTON:
16 DEVONSHIRE STREET...DAMRELL & MOORE, PRINTERS.
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ASTRONOMICAL DIMENSIONS.

	Mean Distance from the Sun in million miles.	Mean Diameter in Miles.	Time of Sidereal Revolution.	Hourly Motion in Revolution.	Rotation on Axis.	Orbit varies from plane of Earth's Orbit.	Longitude of Perihelions.	Longitude of Ascending Nodes.	Inclination of Axes from Perpendicular.	Axis inclines towards Longitude.	Aphelion distance from the Sun.	Relative bulk compared with the Earth.	Rel. Solar Heat, Light, and Attraction.
	miles.	miles.	y'rs. d's.	miles.	hours.	°	°	°	°	°	miles.	times.	times.
Sun,		886,952			610				$7\frac{1}{3}$	71		1;396,856.	
Mercury,	37;	3,200	88	109,757	24	7	74	46	30?	?	44;600,000	·056'5	6·670
Venus,	68;	7,700	224	80,293	$23\frac{1}{2}$	$3\frac{1}{2}$	129	75	75	320	68;560,000	·882'8	1·910
Earth,	95;	7,912	1	68,288	24		100		$23\frac{1}{2}$	90	96;600,000	1·	1·000
Moon,	$\frac{1}{4}$	2,162	27	70,000	656	5			5		96;840,000	·750'0	1·000
Mars,	142;	4,189	1 321	55,332	$24\frac{1}{2}$	2	332	48	$30\frac{1}{3}$	140	157;430,000	·143'3	0·430
Vesta,	225;	270	3 230	44,435	?	7	250	103	?	?	245;550,000	·000'$\frac{1}{2}$	
Juno,	252;	1,400	4 131	41,799	?	13	54	171	?	?	317;000,000	·005'5	
Pallas,	263;	2,100	4 222	41,009	?	34	121	173	?	?	336;500,000	·016'8	
Ceres,	263;	1,600	4 222	41,051	?	$10\frac{1}{2}$	147	81	?	?	283;600,000	·008'0	
Jupiter,	490;	87,000	11 314	29,943	10	$1\frac{1}{3}$	11	98	2	190	513;600,000	1,281·000'0	0·037
Saturn,	900;	79,000	29 167	22,111	$10\frac{1}{2}$	$2\frac{1}{2}$	89	112	31	80	950;000,000	995·000'0	0·011
Uranus,	1,900;	35,000	84 5	15,592	?	$\frac{3}{4}$	168	73	?	?	1'988;000,000	77·000'0	0·003
Neptune,	2,850;	35,000	166		?				?	?			0·001

Entered, according to Act of Congress, in the year 1849, by
ENOS STEVENS,
In the Clerk's Office of the District Court of the United States for the District of Massachusetts.

PREFACE.

THIS book is designed to teach Astronomy as it is now understood by the best astronomers. I have left out the history of the science, and also the illustrations and explanations of its various details; and have confined myself to a simple narrative of the heavenly bodies. By leaving out the history of the science, I teach astronomy without first preoccupying the minds of learners with the incomplete, incorrect, contradictory, and absurd theories of former ages; and I avoid illustrations and explanations, because I have always found that a simple narrative of the facts of this science can be much more easily learned and remembered than the best illustrations and explanations that I have ever seen. But the greatest advantage of this method of teaching is that it keeps together the principal facts constantly before the astronomer's mind, in all subsequent contemplations of the subject, instead of the various and incongruous explanations and illustrations of its different details. After having been taught in this manner, astronomers will always be prepared to contemplate and describe any part of the celestial scenery, as a portion of the whole mechanism of the heavens, as it really exists; rather than by the detached and contradictory explanations of its various phenomena. Moreover, this book is a constant and minute description of the positions of all the planets for every day of the time for which the tables are already calculated; and I intend to publish soon an ephemeris for many subsequent years, with a diagram on a larger scale, so as to give, at the same time, the ephemeris of all the satellites of the solar system. The numerals in this book are punctuated by placing an inverted period for a decimal point; and then a comma between the third and fourth integers; a semicolon between the sixth and seventh integers; and an apostrophe between the ninth and tenth integers; but their correlative decimal places are indicated by these same characters inverted.

When this book is used, either in schools or families, I do not recommend any of it to be committed to memory verbatim; but think it should be read through often, and that the learners should place the globules correctly in every respect upon the diagram, according to the ephemeris for the passing day; and also frequently set them on for days several months before or afterwards. By doing this a few times, every one will soon become so familiar with the diagram as to know all the principal stars and planets by their relative positions in the firmament, whenever they see them. If you have this work at hand, while you are reading any book or newspaper article on astronomy, you can at once conceive how every phenomenon described in them is located with reference to any or all the globes of the solar system, and thus comprehend it as a part of the multiform phenomena of the universe. To the students of surveying and navigation, it will be peculiarly gratifying, because it furnishes a practical location of all the astronomical facts or data given in the theory and practise of those sciences.

EPHEMERIS OF STORMY DAYS.

Date. 1847.		Mercury.	Venus.	Earth.	Moon's G. Long.	Mars.	Vesta.	Juno.	Pallas.	Ceres.	Jupiter.	Saturn.	Georgian.	Neptune.
January	1	185	190	101	99	219	166	256	22	67	74	332	13	
“	16	23	314	116	288	227	170	258	25	70	75	332	13	
February	1	278	339	132	145	235	175	261	29	73	76	333	14	
“	17	331	4	149	357	243	180	263	33	77	78	333	14	
March	2	34	25	162	165	250	184	265	36	80	79	334	14	
“	17	125	49	177	5	258	188	268	40	83	81	334	14	
April	1	193	73	191	198	267	192	270	44	87	82	335	14	
June	2	58	174	252	280	304	212	281	64	101	87	337	15	328°
September	11	137	335	348	188	8	244	299	104	125	96	340	16	
“	25	197	357	2	15	16	249	302	110	129	97	340	16	
October	11	245	22	18	221	26	254	306	117	134	98	341	16	
“	24	281	43	31	38	33	258	308	120	136	99	341	16	
November	7	327	66	45	218	41	263	311	126	140	101	342	17	
“	20	29	87	58	31	49	267	314	131	143	102	342	17	
December	4	114	109	72	214	56	272	317	135	147	103	343	17	
“	19	186	134	87	55	64	276	321	141	151	104	343	17	
1848.														—
January	6	242	163	105	285	74	282	325	147	155	105	344	17	
“	20	281	185	120	120	181	287	329	151	159	107	344	17	
February	16	29	229	147	116	94	294	335	159	165	109	345	18	
May	8	358	359	228	118	132	320	360	180	186	116	348	19	
“	22	78	21	241	289	138	323	3	183	189	117	348	19	
June	20	213	68	269	312	151	332	14	191	197	119	349	19	
July	17	290	111	295	308	163	340	24	197	204	121	350	19	330°
August	16	65	160	324	345	176	348	35	203	210	124	351	20	
“	29	142	181	336	165	182	351	40	206	213	125	351	20	
September	14	207	207	352	9	189	355	46	210	217	126	352	20	
“	28	248	229	5	198	195	359	52	213	220	127	352	20	
October	14	293	255	21	47	203	4	59	216	224	128	353	20	
“	29	349	279	36	242	210	8	65	220	227	130	353	20	
November	11	59	299	49	55	216	11	70	222	230	131	354	21	

The object of this table is to show that the greatest agitations of the Earth's atmosphere, occur when the Sun and many planets are so arranged as to conspire with the Moon, so as to cause unusually high aërial tides. Such combinations of the globes of our solar system, have always been immediately followed by very strong winds for a day or two; and if there have been local causes of rains or gales, then violent rains and storms have spread over vast regions. The progress of the rain or snow or gale is many miles per hour; for the rain or snow formation spreads in the atmosphere in a manner very analogous to the fire on a prairie, or in the dry leaves of a forest, and the rain or snow is the residuum like the ashes. In the notes at the bottom of the ephemeris of every month, all such combinations of the heavenly bodies are mentioned, as a prognostication of the weather; and also the days on which the Moon crosses the plane of the Earth's equator, when it causes its lunar equinoctial wind, analogous to the semiannual equinoctial storms.

RUDIMENTS OF ASTRONOMY.

§ 1. When we look at the stars on several clear nights, we perceive that we are surrounded by a vast spherical void, with an immense number of fixed stars shining upon us from every direction, and from immeasurably great distances. But when we look more attentively, we occasionally see a few stars moving far within the spherical void, and often passing before the fixed stars, and sometimes even before each other. The names of the moving stars that we can see without the assistance of a telescope are the Sun, Mercury, Venus, Earth, Moon, Mars, Jupiter, and Saturn; and by the help of telescopes, we can see Vesta, Juno, Pallas, Ceres, four moons with Jupiter, seven moons with Saturn, Uranus and its six moons, and Neptune with one or two more. Besides these planets and satellites, four others have very recently been discovered in the vicinity of the orbits of Vesta and Juno; and they have been named Astræa, Hebe, Iris, and Flora. Of these four very little is known except their distances from the Sun, and their time of revolution. Because they are so small and little known, and as their ephemeris is not calculated, their orbits will not be found on the Diagram.

§ 2. The object of the science of Astonomy is to teach all that is known of the stars, and to show how to take practical advantage of their motions; to determine the latitude and longitude of places on the earth, and their courses and distances from each other; the seasons of the year; the length of the days and nights at all seasons; the changes of the Moon; the tides; and to prognosticate when long and hard storms, or calm and clear weather will be most likely to occur. But the object of this little book is merely to give some correct general ideas of the direction of a few of the fixed stars; and the distances, motions, and sizes of the planets; and to show where every planet of our solar system will be on any required day. To give a proper general idea of all the planets at once, with all their sizes, motions, distances, and daily relative positions for a long time to come, I have delineated their orbits nearly as they are, and as I suppose they must appear to one stationed near the most northerly point of the apparent spherical void, who is looking south at the Sun, and the circumvolving planets, floating in the centre of such a space on a level before him. Thence, the planets seem relatively near the Sun, revolving round it by going up on the right and moving over towards the east, and so on round from west to east. Every planet revolves in nearly a circular orbit, but different planets at different distances; yet the more distant move in nearly the same perpendicular plane, out one beyond the other, like wheels around wheels on the same centre. The amount and direction of the variations of the plane of their orbits from that of the Earth, is indicated on the Diagram. The diameters of their orbits are not shortened according to perspective, because it would scarcely be appreciable in any orbit except Ceres and Pallas. This plan was pursued so as to show distinctly the direction of their eccentricity in revolving round the Sun.

EXPLANATION OF THE DIAGRAM OF THE SOLAR SYSTEM.

§ 3. When you wish to study the Solar System, face southward, and suspend the Diagram of the Solar System perpendicularly before you. The central spot represents the Sun's place. The elliptical lines around the Sun represent the orbits of the planets, whose names they severally bear, drawn on a scale of a hundred million miles to the inch. The straight lines from the Sun are drawn at every tenth degree of heliocentric longitude, and numbered from the vernal equinox. To every Diagram belongs a set of small globules, each of which has a wire extending through it, and projecting out and sharpened, so as to serve as a brad, with which to make it stick upon any required place on the Diagram, by thrusting it into the paper. The larger globules represent the larger planets, and are marked with the name or character of the planet they severally represent. The largest represents the Sun and must always be placed upon the central spot. The smallest globules are to represent the very small planets and the moons.

The Astronomical Characters are

☼ ☉ Sun,	⚵ Juno,	♅ Uranus,	☾ Last Quar.
☿ Mercury,	⚴ Pallas,	♆ Neptune,	☌ Conjunction,
♀ Venus,	⚳ Ceres,	● New Moon,	☍ Opposition,
⊕ Earth,	♃ Jupiter,	☽ First Quar.	☊ Ascen. Node,
♂ Mars,	♄ Saturn,	○ Full Moon,	☋ Des. Node.
⚶ Vesta,			

The Arabic numerals near the orbit of Jupiter indicate the number of degrees of the heliocentric longitude; but the Roman numerals near the orbit of Saturn are intended to assist in giving the geocentric Right Ascension of objects in the time of the Earth's rotation.

§ 4. THE ASTRONOMICAL EPHEMERIS shows in what heliocentric longitude, or direction from the Sun, every planet is on every day for several years; and also the Moon's daily geocentric longitude, together with the time of its various relative positions as to the Earth and Sun. To place the representative globules upon the Diagram at their proper places for any certain day, find that day in the Astronomical ephemeris, and place the several globules upon their orbits at the longitude that the table indicates for every one for that day.—When the globules are all thus put on, you have a complete miniature of the relative courses and distances of the spheres of our Solar System for that day. Proceed in the same manner for the next day, and for many subsequent days, until you can readily put them on for any required day. In order to reduce the size and expense of the Diagram, the orbits of Uranus and Neptune are not given; but they may be set on a straight line, made in continuation of those already given, and thus may it be rendered complete and available in all particulars for many years. Put Uranus on at 19 inches from the Sun, and Neptune at 28 1-2 inches, in the longitude that the daily ephemeris indicates.

§ 5. By noticing their daily advancements for a long time, you perceive that they all revolve over the Sun from west to east, and continue to move round always in that direction. You also see that the nearer the planets are to the Sun, the faster they advance; but the farther off, the slower. This applies not only to the different planets, but also to the different portions of the orbit of the same planet, according as it is moving farther from, or nearer to the Sun. The average hourly motions of the several planets in their revolutions are given in the table of dimensions. The distance that any planet is from the Sun, on any particular day, is the length of its radius vector for that day. The letter P on every orbit indicates its perihelion point, where the planet is nearest the Sun; and the diametrically opposite point is the aphelion, where it is farthest from the Sun.

The planes of the orbits of all the planets are nearly in the same perpendicular plane around the centre of the Sun, but no one is quite in that of any other; and a part of the orbit of every planet is north of the plane of the Earth's orbit, and just half of its longitude is south of it while they revolve round the Sun. But their difference from each other is only a very few degrees, and hence, in the Diagram they are all drawn as if they were in the same plane. The part of every orbit that is north of the Earth's orbit is indicated by a continuous line; and the rest of it, which is south of the Sun, by a dotted line. The table of Dimensions shows how many degrees the plane of every orbit varies from the plane of the earth's orbit. The ascending node of a planet is where it passes through the plane of the earth's orbit and revolves north of it; and the descending node is the point where it passes through towards the South, and is always 180° from the ascending node. When a planet enters upon the continuous line of its orbit, it is at its ascending node; and when it begins on the dotted line, there is its descending node. The number of million miles that every planet is north or south of the Earth's orbit at various stations, is indicated by the numerals along their orbits. To represent the various inclinations of the different orbits most practically in placing the representative globules upon the diagram, and the amount of their distances north or south of the Sun, first, put on the Sun firmly, and then put on the Earth so that their centres will be at equal distances from the Diagram, which will be best done by thrusting in their several brads to the mark. When the other planets are near their nodes, put them on at the same distance from the Diagram as the Earth, and thrust in their brads to the mark. But as they advance along the dotted line from their descending nodes, thrust in their brads farther and farther every day, until they severally arrive at the southernmost point of their orbits. From this point, leave them out a little more and more every day until they come to their ascending nodes, where they severally must be just as prominent as the Sun and Earth. But as they advance farther and farther from their ascending nodes, along their continuous lines, let the brads be left farther and farther out from the Diagram, until they come to their northernmost point. From this point, the brads must be gradually thrust in farther and farther every day, until the planets return to their descending nodes. The numerals along the orbits of the planets show how many hundredths of an inch the planets are distant forward or beyond the globule that represents the Earth. Although the planets are often in the same longitude with each other, yet they seldom pass directly one between the Sun and the other; but when they do, the one nearest the Sun performs a transit before the other. Moreover, three or more planets may be in a straight line with each other when they are in very different longitudes. On the Diagram, the inclinations of the planes of the orbits of the different planets are represented as if perpetually stationary, although they are all gradually becoming less and less different from each other, as if they were ultimately designed to revolve exactly over each other.

STARS AND CONSTELLATIONS.

§ 6. But if we now follow out the plane of the Earth's orbit for more than twenty trillion miles, or three miles on the scale of the Diagram of the solar system, we shall find an immense multitude of stars in every direction. Indeed they seem to surround the Solar System, at more than that distance, on every side, so as to appear to inclose it in a spherical space. The principal stars in the different directions from the Sun are supposed to be divided into a certain number of clusters, each of which has a distinct name; and even the several stars that make up every cluster are either named or numbered. Those clusters or constellations that are situated in the planes of the orbits of the principal planets are the twelve constellations of the Zodiac, each of which extends about 30° or one twelfth of the circuit of the heavens. The names of the constellations of the Zodiac are Pisces, Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus and Aquarius. The immense distance of these stars precludes the possibility of representing them proportionably on the Diagram, and therefore they are omitted; yet for the sake of communicating an idea of the location of the various constellations, I have put their names on the outside of the Diagram, on the side of the Sun on which they are severally to be found. I have also put on the names and a line towards the principal fixed stars in several of them, especially the nine stars, from which the angular distance of the moon is taken in calculating the longitude of stations on land, and of vessels at sea. The dotted line indicates the star to be in South latitude, and the continuous line, North latitude. A heavenly body is said to be in a certain constellation when it is in that segment of space which lies towards and includes that constellation; that is, every constellation, whether in the Zodiac or not, gives its name to the whole of the segment of space in the direction in which we look at it. Hence any planet or other heavenly body may be said to be in a certain constellation at one time; and after it, or the observer, revolves a considerable amount, it will seem in another constellation. Of the miscellaneous stars near the orbit of Saturn, those on the outside are north of the plane of the Earth's orbit, and those within, are south. The first letter of the name of every star is at the longitude of the star referred to.

Moreover, a planet or other heavenly body will seem in one constellation, if viewed from the Earth; but in another if viewed from the Sun. The direction that a planet, or other heavenly body is from the Sun, is its heliocentric position; and its direction from the Earth is its geocentric position. Hence we speak of heliocentric longitude, and geocentric longitude, although both are reckoned from the same plane in space, but around different centres. The daily positions of the planets are given in the Ephemeris according to their heliocentric longitude; but the position of the moon is given according to its geocentric longitude, reckoned around the centre of the Earth.

When Mercury or Venus are on the opposite side of the Sun from the Earth, then their apparent geocentric motions through the constellations are faster than their real revolutions round the Sun, on account of the Earth's motion in the opposite direction. For while they go up, the Earth goes down; or while they go to the right, the Earth goes to the left. But when the Earth and Mercury or Venus are on the same side of the Sun, then they seem to move across the field of view in the opposite direction, or to retrograde through several constellations. Again, when in that part of their orbits which extends towards where the Earth then is, they seem neither to advance in longitude, nor to retrograde through the constellations; but in reality they are either approaching, or going away past the Earth in their revolutions round the Sun. Something of this sort of apparent retrograde motion occurs in relation to the positions of all the planets whose orbits are larger than that of the Earth. That is, when the Earth and any more distant planet are on the same side of the Sun, then the more distant planet seems to retrograde, to the amount of the difference of the Earth's motion faster than the more distant planet. For example, during February, 1849, Jupiter will appear to retrograde, and Saturn during September.

When a place on the Earth is directly between its centre and the Sun, it is noon at that place; and when the earth has made a half rotation, it will be midnight there, and we may see the stars in the adjacent hemisphere of the abyss of space. Places towards that part of the orbit that is just passed through, have the setting sun in their western horizon; and places towards the future orbit, have the rising sun in their eastern horizon. But when the sun is above the horizon of a place, all the stars above the horizon are invisible, on account of the Sun's dazzling light. But wherever the Sun is not above the horizon of a place, you may see all the stars and planets that are then in the upper hemisphere of space bounded by the visible horizon. When any planet or star is visible soon after sunset, it is an Evening Star. But if it is not visible at sunset, it will be visible, or very near the Sun in the morning. If it is visible a little before sunrise, it is a Morning Star.

To determine definitely from the Diagram in what constellation any planet or star will appear from the Earth, take a thread about a yard long, tie the ends together, and loop the middle over the brads of both the Earth and the Sun. Now let that part of the thread which passes around the Earth, extend close along straight by the given planet, or star, to the margin of the Diagram, and at the same time, hold the other part of the thread which passes around the Sun parallel to that around the Earth. When the two parts of the straight thread are thus held parallel to each other, and one extending from the Earth to the planet, or star, and the other part parallel to it from the Sun, then read off the constellation, or degree of longi tude on the thread that extends directly from the Sun. But to determine from the Diagram how many hours before, or after midnight, a certain planet or star will be in the meridian of any place; first determine its geocentric longitude by the above directions, and then count the hours, and parts of an hour, between it and the heliocentric longitude of the Earth. If its place is geocentrically west of that of the Earth's from the Sun, then it will be on the meridian before midnight; but if east of the Earth's place, then it will be in the meridian after midnight. But because Mercury and Venus are always very near the Sun, they always rise and set near the same time with the Sun; therefore they are never seen for nearly 3 hours before or after midnight.

THE MOON.

§ 7. In its revolutions round the Sun, the Earth is accompanied by the Moon, which continually moves round the Earth in the same manner that the Earth revolves round the Sun. The column in the Ephemeris, under the word "Moon," shows in what direction from the Earth the Moon is on, every day, at about seven o'clock in the morning of civil time, in longitude seventy-five degrees west of Greenwich. During their mutual revolutions round the Sun, the Moon and Earth revolve round each other about twelve and a half times. The globule representing the Moon must be stuck upon the diagram very near the Earth, and in a direction from it parallel to the line representing the same longitude round the Sun. The Moon and the Earth revolve in nearly circular orbits round the Sun, and yet, if you merely compare their relative positions with each other, they seem only to revolve round each other. The plane of the Moon's orbit round the Earth is not parallel to the Earth's round the Sun, but differs from it about five degrees. The amount of the difference between the planes of their orbits always remains about the same, while the direction of the inclination of the Moon's orbit is so rapidly changing all the time, that it slants towards every point of the circle in about eighteen years. In the same column of the Ephemeris with its longitude, you may see on what day the Moon passes through its nodes; and also through its perigee and apogee which are analogous to the perihelion and aphelion, as to revolving round the Sun. The character ☊ in the table is set opposite the day in which the Moon passes its ascending node, and ☋ the descending node; P. the peregee; and A. the apogee. In following the revolutions of the Moon a few years, you perceive that its nodes are rapidly retrograding or going back, and revolve quite round the Earth in about eighteen years and eleven days, but its perigee and apogee sometimes advance and at others retrograde in longitude. In placing the Moon upon the diagram, observe always to thrust in its brad so as to indicate correctly whether the Moon is north or south of the Earth, and how much. From the ascending to the descending node, it is north, and from the descending to the ascending node it is south of the Earth. When midway between its nodes, it is about twenty thousand miles from the plane of the Earth's orbit; and when 30° from either node, is about ten thousand miles off, and at other points it is proportionably distant north or south of the Earth's orbit.

ECLIPSES.

§ 8. When the Earth and Moon arrive at the same range of longitude, the one will not eclipse the other from the light of the Sun, unless they are in or very near one of its nodes. For if they are midway between its nodes, then the centre of the Moon is 20,000 miles north or south of the centre of the Earth, and the shadow of the one cannot extend in width to the body of the other. But if they are within 16 1-2 degrees of its nodes, then, when the Earth passes into the same heliocentric longitude with the Moon, a part of the shadow of the Earth must extend over a part or the whole of the Moon. If this occurs when the Moon is within two or three degrees of its nodes, then the Moon will be darkened by the shadow of the Earth for several hours. When the Moon is within 10 1-2 degrees of either of its nodes, and comes between the Earth and Sun, the Moon's shadow will touch some part of the Earth; but as the Moon is so much smaller than the Sun, and also smaller than the Earth, its shadow never gets to darken a space on the Earth over two hundred miles in diameter; and if it is exactly at its nodes, either it may be so far off that the shadow comes to a point before it reaches the Earth, or there will be a total eclipse of the Sun from a small place on the Earth near its equator. If the Moon is too far from the Earth, there will be an annular instead of a total eclipse. In an annular eclipse the Moon seems to pass centrally before the Sun, yet, when before its centre, it shows a bright ring all around outside of the Moon.

ATTRACTION OF GRAVITATION.

§ 9. By still nicer observations of the motions of the planets and their satellites, we see that a mutual attraction of gravitation exists between them all; and that they are prevented from all falling together by the momentum of their motions. The force of attraction varies inversely as the squares of their distances. When the revolving globes move so fast that the centripetal attraction is not sufficiently strong to bend them continually out of a straight line into a circle, the planets then gradually recede from the Sun. In going off, their motions are continually retarded, as a stone would be, when thrown up from the surface of the Earth. Yet the retardation of going off is greater than the decrease of the force of attraction at a greater distance. But when their motions have been so reduced that the central attraction can draw it gradually round into circular motion, they describe nearly circular lines. But when the form of the line of motion gradually changes from receding to circular, it always soon goes over to approaching the centre of gravity and motion, and then the centripetal force gets the advantage of direction, and makes the revolving bodies gradually approach the centre. As they approach, their motions are accelerated, like the velocity of a stone falling towards the Earth, and it soon becomes so rapid that the centripetal force cannot bend it to circular motion, and then it gradually recedes. From the time a revolving planet is farthest off in one revolution, until it has approached the centre and is farthest off again, it has usually revolved a little more than once round the centre, and hence the orbits are not perfectly elliptical, but a sort of spiral line through space, and they probably never revolve twice along the same region. If two bodies revolve round their common centre of gravity without being influenced by other transient bodies, they would revolve in perfect ellipses. But while the planets revolve around the Sun, they are frequently drawn forward and occasionally backward, each by the influence of the others. In this manner the Moon's apogees and perigees are very much drawn backward and forward by the Sun. Hence the aphelions and perihelions of all the planets are continually changing their longitudes, and the same principles of revolution apply, and in a greater degree, to the motions of the satellites round their several planets. In the cases of the planets, the revolutions of their aphelions are so little at any one revolution, that their progress is scarcely appreciable in less than one hundred years. But in relation to the satellites it is very rapid, and soon would bring the aphelions on the opposite side of the centre.

ROTATORY MOTIONS.

§ 10. When we direct our attention more exclusively to the surfaces of the celestial globes, we immediately perceive spots upon them, and soon see that all the planets rotate, or roll round their own centres from west to east, in the same direction that they revolve round the Sun. The time that the several planets take to rotate is given in the table of Dimensions. The small wires, where they pass through the globules, represent the axes of their rotations ; but the rest of the wires are merely the handles or brads that must be thrust perpendicularly into their places on the diagram. The angle in the wire represents the inclinations of the various axes from the perpendicular to the plane of the Earth's orbit. The axes of the different globes must always point in certain different directions, although the axis of the same globe must always point in very nearly the same direction for any small number of years. The table of Dimensions shows towards which line of longitude the several axes should incline; and also the number of degrees that the axes vary from the perpendicular to the plane of the Earth's orbit. Astronomers have not yet discovered the rotations of Vesta, Juno, Ceres, Pallas, Astræa, Hebe, Iris, Flora, Uranus, nor Neptune, and their observations on Mercury are somewhat indefinite, especially as to the direction of its axis. The direction of the axis of Uranus is inferred from the directions of the revolutions of its moons. But the rotation of Uranus and Neptune has not been directly discovered.

DAY AND NIGHT.

§ 11. The Sun is continnally emitting light and heat in every direction, and hence keeps the surface of the hemisphere, turned towards its rays, constantly illuminated by solar light ; while the opposite side of every planet, being turned from the Sun, is without solar light and hence is in darkness. But when the planets rotate with their axes perpendicular to their radius vectors, then all parts of their surfaces are brought successively into light and darkness; and every place upon their surfaces then enjoys a duration of sun-light and darkness equal to those of every other place on the same planet. Jupiter's axis is always nearly perpendicular to its orbit and radius vector, and hence the time of sun-light and darkness are of equal length at all places on his surface. But the axes of the other planets vary considerably from the perpendicular to the plane of their own orbits, and are perpendicular to their radius vectors in only two points. These diametrically opposite points are their equinoxes. From that equinox through which the Earth passes in September, celestial longitude is reckoned; but the equinoxes of the other planets are at different longitudes. As the various durations of sun-light and darkness on the different planets are very analogous to those of the Earth, a good general idea of them all may be acquired by examining merely the Earth. The equinoxes of the various planets will always be just ninety degrees from the line of longitude towards which their several axes incline.

LENGTH OF DAY AND NIGHT.

§ 12. When the Earth revolves from the right or September equinox, the northern pole of its axis gradually recedes from the Sun more and more, and rotates in darkness until the Earth has revolved half of its orbit. At 90 degrees of longitude, the north pole is 23 1-2 degrees from the sun-lighted portion of the Earth's surface, and the part not daily illuminated has gradually extended from a mere point at the north pole, until it extends 23 1-2 degrees from it in every direction. But while a portion of the northern hemisphere of the Earth has been rotating many times in continuous darkness, a similar portion of the southern hemisphere has been exposed to continuous sunlight for as many rotations. As the Earth revolves from 90° to 180° of longitude, its axis gradually approaches the perpendicular to its radius vector, and the continuous dark and light portions of its surface gradually become narrower, until it arrives at the March or left equinox, when the sun-lighted and dark parts of the days are again of equal length throughout its whole surface. From 180° to 270° of its revolutions, the south pole of the Earth advances farther and farther into continuous darkness, and the northern regions have continuous sun-light as long as the opposite region is in darkness. From 270° to the first degree again, the continuous dark and light portions of its surface become gradually narrower, until the sun-lighted part of every rotation is just equal to its dark part at every place. Places on the Earth near its equator, will always have about equal portions of light and darkness every day; but as places are farther from the equator, they will have the greater part of their rotations in the sun-light when one pole is turned towards the radius vector during their summer; and more than half of them in darkness while the other pole is nearer the Sun, during their winter. The farther north or south the places are, the greater will be their extremes of long light and of long darkness. At the poles there is alternately six months light and six months darkness. Places 23 degrees from either pole have several rotations of continuous light in summer, and of continuous darkness in winter, and then the duration of their sun-light and of their darkness gradually changes from one extreme to the other. The intermediate places have intermediate exposure to light and darkness.

The more slanting the axis of a globe is, the wider will be the circle in which the light and darkness will continue one or more rotations. When the axis is as slanting as that of Venus, then the polar circles extend to within 15° of its equator; and the sun becomes perpendicular to all places more than 15° from the poles. At Mars and Saturn, the variations as to solar light and darkness of the days will be very analogous to those of the Earth, although their years are much longer and the days of Saturn much shorter than the years and days of the Earth.

TIME.

§ 13. The exact time of a revolution of the Earth is ascertained by observing the time from when the Earth is exactly opposite any certain star in the Zodiac, until it is exactly in the same heliocentric longitude again under that star; when it will have been moving 365 days 6 hours 9 minutes and 10 3-4 seconds, which is called a SIDEREAL YEAR. The times of the revolutions of all the other planets are ascertained in the same manner; but the exact number of minutes and seconds of each one is attained by taking the average of a great number of revolutions. A year on the Earth is the time intervening between, when the poles of the Earth are perpendicular to its radius vector at the right equinox through which it passes in September, and its arrival at a point in its orbit, where its poles are again perpendicular to its radius vector, near the previous September equinox; and takes 365 days, 5 hours, 48 minutes and 48 seconds. The difference of 22 minutes and 23 seconds, between the Earth's revolutions and its years, results from the Moon's acting on the protuberance around the Earth's equator, and thereby continually drawing its poles easterly a very little, so that the plane of the equator is tilted westerly, making its axis come to be perpendicular to the radius vector before a revolution is completed. The Moon thus draws forward the poles of the Earth in nearly the arc of a circle of 47° diameter, as if it would complete the circuit in about 25,000 years, in which time, the equinoxes would pass successively through the whole orbit, and carry the seasons along with them at their present relative distance from the equinoctial points. Consequently, at the end of about 12,000 years, when persons place the globules upon this diagram of the solar system, they will make the Earth's axis slant downwards, instead of upwards, as at present; and then they will have Winter in the Northern hemisphere, while the Earth is passing through those constellations where they now have their Northern Summer.

While the Moon is thus drawing forward the poles of the Earth through a revolution of about 47° in diameter in about 25,000 years, the Sun acts on the same protuberance and is continually drawing the poles of the Earth towards the poles of the plane of the Earth's orbit, at such a rate as to make them coincide in about 150,000 years. Then, astronomers will put the Earth upon the diagram with its axis perpendicular; and a perpetual Spring will reign incessantly over the whole Earth as on Jupiter; and the dark and illuminated portions of the day will be equal on every region of its surface. But as the poles of the Earth are subject to both these influences at the same time, they will traverse an intermediate line between them, and thus describe a spiral line, revolving six times around the poles of the plain of its orbit before the one pole will coincide with the other. Moreover, this coincidence of the poles of the daily rotation of the Earth with the poles of the plane of its yearly revolution, is slightly modified by the continual, though very slow transposition of the plane of the orbit of the Earth's revolution round the Sun. When you look on the diagram, you see that the orbits of all the planets are north of that of the Earth on the left hand side of the Sun, but south of it on the right; and therefore the effect of their attraction will tend to tilt round the plane of the Earth's orbit towards the north on the left, and towards the south on the right, as if the planes of the orbits of all the planets were ultimately designed to coincide with each other. But the influence of the attraction of the other planets will probably never vary the plane of the orbit of the Earth round the Sun over two or three degrees.

EQUATION OF TIME.

§ 14. A vertical plane extending north and south through any place on the Earth, and extending indefinitely into space on the same side of the Earth's axis, is the meridian of that place. The exact time of the ROTATION of the Earth is ascertained by observing the time from when any certain star is on the meridian of a place, until its meridian passes through the same star again. The Earth always rotates at the same uniform rate, and hence the sidereal rotations are always just 23 hours, 56 minutes, and five seconds. A DAY is the time from when the Sun is in the meridian of any certain place, until it is in the meridian of the same place again. A day exceeds a sidereal rotation by the time of the same number of degrees of rotatory motion that the Earth performs of its revolution round the Sun, during a rotation and until it brings the given meridian into the Sun again. Because the Earth moves with different velocity in the different parts of its orbit, therefore it advances unequal quantities in each rotation; and hence requires unequal portions of a rotation to bring the given meridian into the Sun, and makes the length of the days differ from each other a few seconds. The mean or average length of the days is 24 hours; of which 365 days, 5 hours, 48 minutes, and 48 seconds, make a year. Mean days are indicated by clocks; but as the actual days are of various lengths, sometimes their noons will come before and at others a little after that indicated by the clocks. Near its perihelion, that is, during December and January, the Earth revolves faster than average, both because the velocity per hour is faster, and also because the degrees of its orbit here have a shorter radius vector, and hence a shorter circuit. But near its aphelion, during June and July, it revolves slower in its orbit, because it is farther off from the centre of motion, and because it is moving slower per hour. When the Earth passes through the greatest number of degrees of its orbit in a given time, then it requires the greatest part of a rotation to bring the given meridian to the Sun, so as to complete a day; and hence in the months of December and January, the days are a few seconds longer than average; while in June and July they are shorter.

§ 15. But the principal cause of the unequal length of the days, and into which that resulting from unequal velocity in its orbit is merged, and nearly lost sight of, is the variation of the Earth's axis from the perpendicular to its radius vector. When the Earth is at the equinoxes, the solar days are a little shorter than the mean or clock days of 24 hours; but as the axis of the Earth departs from the perpendicular to its radius vector, the Earth has to rotate more than it otherwise would to bring the given meridian into the Sun; and hence the rotations of the Earth there seem to lose on clock time, from near the equinoxes, until it is 90° from them; and thence it approaches clock time again, until it arrives at the other equinox. That is, in other words, the variation of the Earth's axis from the perpendicular to the radius vector, results as if an extra part of a rotation had to be allowed for in time, and that the farther it varied, the more time the Earth seemed behind its average or mean time of bringing its meridians to the Sun. When the Earth is near its equinoxes, its days are a very few seeonds each shorter than the mean day, according to a perfect clock; and when midway between them, the days are a little longer than the mean days; but when at about 45 degrees from either equinox, it makes the days of very near the mean length. The inequality of the Earth's revolution in its various parts makes the Earth seem dilatory, compared with the clock, when it is in its perihelion, which is at about 100 degrees of longitude, which is only ten degrees from midway between the equinoxes; and the inclination of its axis to the perpendicular to its radius vector, makes the days too long at about the same portion of its orbit; hence, when the Earth passes through that portion of its orbit, it will be behind the clock by the amount of the effects of both these causes together; but while it is near its aphelion, or 280°, the irregularity of the velocity of its revolution would make the days a little shorter than the clock, but the inclination of its axis would make them much longer than the mean or average days of the clock; and therefore the days are then longer than the mean days by the difference of the effects of these causes; and hence the Earth is then a little behind the clock in bringing on noon.

§ 16. The only allusion that the science of astronomy contains to the Christian religion is, that the astronomer's clocks for marking mean solar time, are always supposed to be started at Christmas, on December 25, where the Earth is at 94° of longitude. In this part of its orbit, the solar days most exceed the mean day, from the combination of both the causes just described; but the solar days here begin to exceed the mean clock days less and less every day until the 11th of February, at 143° of longitude, where the solar days are just equal to mean days, but by having made longer days previously, the Earth has here got behind the clock 14 minutes and 32 seconds.

From this time until long after it passes the next equinox, the Earth makes the solar days shorter than the mean clock days, and now begins to make up what it recently had fallen behind; and on April 14, at 204°, it has gained on the clock as much as it had before lost, and here solar and mean time again agree, although here, the solar days are the shortest in the year. From here, the Earth still continues to gain on the clock, although less and less every day, until May 15, longitude 234°, where it makes the solar days of mean length; but here the Earth has become 3 minutes and 56 seconds faster than mean time; or, in other words, has brought the meridian to the Sun so much sooner than the clock indicated.

From May 15, in 234° heliocentric longitude, while near its aphelion and the greatest inclination of its axis towards its radius vector, the Earth makes the solar days longer and longer than average, according to the difference of the two above described causes; and by June 14, longitude 263°, it has lost what it had before gained on the clock, so that mean and solar time are again alike, and the solar days are here nearly as long as they were at Christmas. Until July 26, longitude 303°, the Earth still falls behind mean time, although less and less every day; and there it will be 6 minutes and 11 seconds behind mean time, although the Earth will there be making mean days.

From July 26, the Earth again makes the solar days shorter than the mean days, and by August 31, longitude 338°, it amounts to as much as it was lately behind, so that mean and solar time again agree here, where the solar days are about as short as they were on May 15. From August 31 until November 3, longitude 41°, every day is still a little shorter than average, but less and less so, and then it amounts to 16 minutes and 17 seconds; and the last day is of mean length, although it is completed more than a quarter of an hour before the clock indicates it should be finished.

From November 3 until December 25, the Earth makes the solar days exceed the mean days more and more, and at this time, its tardiness will have lost just as much as it had before gained; and hence, here the mean and solar time again agree, as they did at the commencement of the observation, when a perfect clock, making 24 hours per day, began to indicate the noons of mean days. In the course of the year, the clock has been twice faster and twice slower than the solar mid-day indicated its noon; and the clock or mean time just agreed with solar time four times, sometimes one being ahead and sometimes the other, but always varying according to the sum or difference of the two causes already described.

PHASES OF THE MOON AND PLANETS.

§ 17. If a person looks at the celestial spheres from the Earth, he sees only that part of their surfaces which is both shined upon by the Sun and turned towards himself. If any planet and the Earth and Sun are nearly in a straight line with any arrangement that has the Earth and Sun on the same side of the object, then it appears round and bright. But as their mutual positions gradually change, so that the Sun and Earth are on opposite sides of the object, the illuminated circle of its disk gradually diminishes to a mere carved line of light, and finally vanishes from sight, when the Sun illuminates only the side farthest from the observer. This phenomenon of sometimes appearing round and bright, and at others a narrow line of light, or a dark spot in the sky, is most conspicuously seen in relation to the Moon; but it may be easily seen also as to Mercury and Venus, and to some extent as to all the other planets and satellites of our solar system. When Mercury or Venus appear as a dark spot crossing the Sun, they are said to be in a transit. When they or any other heavenly bodies pass directly behind the Sun or Moon, or each other, they are said to be eclipsed from the sight of the inhabitants of that globe from which they are hidden. But when the planets are very near and beyond the Sun, in geocentric longitude, they are invisible, on account of its brilliancy.

When the Moon is directly on the opposite side of the Earth from the Sun, that is, when its longitude from the Sun is the same as that of the Earth; then the fully illuminated side of the Moon is shining on the Earth. The only exception to this is when the Moon is near its nodes, when it will be eclipsed by the Earth. When the Moon is on the side of the Earth towards the Sun, that is, when its geocentric longitude is just 180° different from the heliocentric longitude of the Earth, then the illuminated portion of the Moon is turned from the Earth, and is scarcely visible. From its conjunction with the Sun the Moon's revolutions are counted, and hence it is now called the New Moon, when it enters on a new revolution. If the Moon is now near its node, it will hide the Sun from a part of the Earth. But when the geocentric longitude of the Moon is just 90° from the plane through the Sun and Earth, then only half of the illuminated surface of the Moon is in sight of the Earth. The convex side of its disk is always towards the Sun. These different stages of the Moon, are called, New Moon, First Quarter, Full Moon, and Third Quarter. While the Moon is farther from the Sun than the Earth, it is going through its first and full Quarters; but when nearer the Sun than the Earth, it is in its third and new quarters.

Because Mars and Jupiter are always farther from the Sun than the Earth, they always present more than a semicircle of illuminated disk. But when Mercury or Venus come into the same plane of longitude with the Sun and Earth, they are almost invisible in the dazzling brightness of the Sun, and hence their phases like the new and full moons are scarcely visible; while their intermediate phases are always conspicuous when the planets themselves are visible.

PROGRESSION OF LIGHT, ABERRATION, &c.

§ 18. If we should make very accurate observations of the motions of Jupiter's satellites about the first of February 1849, and therefrom calculate their evolutions for the rest of the year, in June and December we would find that our calculations indicated 8 minutes and 13 seconds too soon; and in September, the phenomena of their eclipses and transits would occur 16 minutes and 26 seconds later than the calculations indicated. When you place the globule planets on the Diagram for the first days of the months mentioned, you at once perceive that in Feb. the Earth is about 95;000,000 miles nearer Jupiter than in December or June; and 190;000,000 miles nearer than in September. Hence light requires 8 minutes and 13 seconds, to travel the diameter of the Earth's orbit. Therefore, this progression of light is to be allowed for in all nice astronomical calculations. Moreover, we should also allow for the motion of the Earth in its orbit, when the light strikes us, and this is the *Aberration of Light.*

TIDES.

§ 19. The time of the Moon's rotation on its axis being the same as the time of its revolution round the Earth, it always presents the same side towards the Earth. But as the Moon's rotation is uniform on its axis, while its revolution round the Earth is accelerated in some parts of its orbit, and retarded in others, it sometimes shows to the Earth's inhabitants a little more on one side, and then a little more on the other, than what it usually does. While the Earth and Moon mutually revolve round their common centre of gravity, their centripetal and centrifugal forces are just balanced at the distance of the Earth's centre from the Moon, as to all bodies on the Earth's surface. But bodies on the side of the Earth next to the Moon, being nearer the Moon by the amount of the Earth's semi-diameter, are partially lifted towards the Moon. On the contrary, those places that are on the side of the Earth farthest from the Moon, are beyond the balance of forces, and all objects there have a centrifugal tendency to fly from the Moon. By the rotation of the Earth, and the revolution of the Moon, every place on the Earth's surface passes through both of these circumstances every twenty-five hours, and hence the air and water are subjected to these influences twice every lunar day, whose mean length is very nearly 24 hours and 48 3-4 minutes. In an analogous manner, the Earth's air and water are influenced twice every rotation on its axis by the attraction of the Sun; and in a very slight degree by the attraction of every one of the planets. When two, or three, or many of the heavenly bodies, are so arranged as to combine their influences at the same time and place, then a much greater effect is produced upon the air and water of those places, than if they acted at different times. From all these influences mainly result the winds and tides.

WINDS AND TIDES.

§ 20. Of all the heavenly bodies, the Moon is very much the nearest to the Earth, and therefore the ratio of the Earth's semi-diameter, to the distance to the Moon, is much greater than the ratio of the Earth's semi-diameter to the distance to the Sun, or to any other globe; and consequently, the agitations of the air and water produced by the Moon on the Earth are much greater than those produced by any other celestial object, and even about double the amount produced by all the others combined. But all the planets are not in the same plane of longitude even once in many million years; and hence, practically, the winds and tides are principally controlled by the Moon. At any given place on the side of the Earth nearest to the Moon, the Moon's attraction is most intense towards elevating the air and water from the general sphericity of the Earth; but the Moon is there acting directly against the Earth's gravitation, and hence, there has accomplished only a very little of the approaching tide, because its attraction is not strong enough to raise the air and water perpendicularly. On the contrary, a place ninety degrees of longitude from the former, is so situated that the attraction of the Moon acts in a horizontal or level direction; and hence might heap up an immense pile of water, and air, if all its force was not neutralized in the balance of the centrifugal and centripetal forces of the revolution of the Earth and Moon around their centre of gravity. But at any given place between 40 and 60 degrees of longitude from being in conjunction with the Moon, where the Moon's attraction draws on a somewhat favorable slant against the Earth's gravitation, although with a somewhat diminished force, it here accomplishes most, in raising the air and water, and thus consummates the tides at about 45 degrees or three hours from the conjunction with the Moon.

§ 21. When any given place has the rising Moon in its horizon and begins to be nearer the Moon than the centre of the Earth is, then its superincumbent air and water are attracted eastward. When the

Earth's rotation has brought this place within 40 or 50 degrees of having the Moon in its Zenith, the water there begins to have a perceptible motion eastward, which gradually increases until the Moon is in the Zenith. For the next 40° of rotation, this current of air and water continues to rush eastward, but is gradually more and more retarded by the Moon's attraction until about three hours or 45 degrees past the Moon, and there it is stopped, and then begins to move westward, with the greatest force of the Moon's attraction, and is heaped upon that which is moving in the opposite direction, and there forms the tide between two and three hours, or about 40° after the Moon has passed the meridian. For the next three hours, the Moon's attraction still continues to lead the current of air and water westward, although with a diminishing force, until the Moon sets, when the Moon's power is neutralized again in the balance of the centrifugal and centripetal forces. For a short time after the place has been ninety degrees past the Moon, the current of air and water continues to run westward by its own momentum; but in about three hours, the friction over the rough bottom of the sea, and the centrifugal force from the Moon, stop its westward motion and make it move eastward again. There is no rise of the tide at this change of the direction of the current of the air and water, because the elements were stopped by their friction on each other, together with the cessation of the Moon's attraction; whereas, before, the current was arrested suddenly and turned back while it was under the most favorable exposure to the Moon's strongest influences.

For the next three hours or 45 degrees of rotation, until the place comes to the meridian opposite the Moon, the current of air and water is accelerated in its motion eastward, by the centrifugal force of the mutual revolution of the Earth and Moon around their centre of gravity. But after the place has passed the opposite meridian, the eastward current is again more and more powerfully arrested by the same centrifugal force, and ultimately turned back upon itself and heaped up; and there makes a tide, in the same manner as was before done by the excess of attraction over the centrifugal force. From this time, the westward current gradually declines in rapidity, with the decrease of the centrifugal force, and by its own friction, and is at length soon stopped, after the Earth's rotation has brought the place nearer the Moon than the Earth's centre, so as to be subject again to the influence of the Moon's attraction, with which I commenced describing the tides of any given place.

TRADE WINDS.

§ 22. Now because the highest swells of the tides are formed by the prevalence of the westerly currents; and because the tides occur farther and farther west every tide by 400 miles or about 24 minutes of rotation, therefore there is left in the air and water a general tendency or motion towards the west from the east, which accounts for the trade winds and the great currents of the ocean running from east to west around the Earth's equatorial regions. In open seas, as the Pacific ocean, the tides usually rise only about one foot; but in narrow bays and the mouths of rivers, they sometimes rise 20 or 30 feet.

SPRING AND NEAP TIDES.

§ 23. In the same manner that the Moon operates, the Sun produces two tides in the air and water every rotation of the Earth; one about three o'clock in the morning civil time, and the other at three o'clock in the evening of every day. Now when both the Sun and the Moon conspire to make their tides at the same time and place, then their joint tide is once and a half or twice as high as when they produce their effects five or six hours apart. This joint high tide occurs at the new and full light of every lunation, and is called the SPRING tide. When the lowest tide occurs at the quadrature of the Sun and Moon, it is the NEAP tide. While the tide is rising at any place, they say it is flowing; and when it is highest for that tide, that it is flood tide or high tide; but while the tide is falling, they say it is ebbing; and the lowest state of the water is the ebb tide. When the Sun and Moon are nearest the Earth, then the spring tides are highest; and the neap tides the lowest, when they are farthest off. If to either or both the solar and lunar tides, there be added the tides produced by either or several of the planets, then there will occur an extraordinarily high tide of water, and an immense rush and agitation of air.

WINDS AND STORMS.

§ 24. When the Moon acts alone, the continual east or trade winds are usually confined to the tropical regions. But when several other large and near celestial globes act together in conjunction with the Sun and Moon to form tides, then an immensely great quantity of air is heaped up, and the supply of air is drawn in impetuously from the temperate Zones, thereby producing the long and violent cold north-east winds of the northern hemisphere, and the cold south-east winds of the southern hemisphere. When the globes have revolved out of conjunction, this great accumulation of aërial tide subsides, and it gradually runs off again towards the polar regions, thereby producing the warm southwesterly winds of the northern hemisphere, and the northwesterly winds of the southern hemisphere. Hence we perceive how our long violent cold north-east storms result from the compound tides of many celestial spheres; and how the warm southwesterly winds, that almost always immediately follow them for a day or two, result from the abandoned heap of air rushing towards its equilibrium again. Now while these winds are sweeping over immense regions of the Earth, if they find local causes of rain, they aggravate them into action over a vast area; and hence these winds are almost always accompanied by rain, violent gales, and even sometimes by hurricanes.

§ 25. To give an adequate idea of the importance of this general description of the rise and progress of storms and rains, and to inspire practical confidence that every such conjunction of several celestial globes with the Moon did, and will always produce a violent storm of wind and rain within one or two days, which will last at least one or two whole days, I have inserted on page four, an astronomical ephemeris of those days on which the storms of 1847 and 1848 did occur. When you place the globules on the diagram for every one of those days, and find that the storms occurred when four, or five, or more celestial globes conspired with the Moon to make great tides for a few days, doubtless, you will have much curiosity to examine the prognostications of violent winds and storms, at the bottom of the ephemeris of 1849. Because such conjunctions have always been immediately followed by the greatest storms, I have thus indicated when all such conjunctions will occur again in 1849, because there is reason to believe that they will still always be immediately followed by storms, of the day of whose coming we desire to foreknow. Mere local causes may palliate, or put off the storm for one or two days after the conjunction, or may continue it a day longer than usual; or may even bring it on with the tide next preceding the approaching conjunction; but still the severest storms of every season will occur at or immediately after the designated conjunctions. Mere local causes may produce violent squalls and whirlwinds, but they will last only a very few honrs, if they do not occur on one of the days indicated in the ephemeris. But if they do occur on one of these days, then there will be a squall or hurricane added to the violence and danger of a storm. Of the violence of the coming storm, you can form a tolerably correct general idea, by considering the nearness, the size, and the number of the celestial globes, by whose agitations of the air it is about to be produced.

EQUINOCTIAL STORMS.

§ 26. From time immemorial, it has been observed that there always are very severe storms, while the Earth is revolving through its equinoxes, which are commonly called the equinoctial storms. These great and violent agitations of the Earth's air and water result from the obliquity of the Earth's axis to the perpendicular to its radius vector. From March until June, in the northern hemisphere, the Sun draws the tides of air farther and farther north every rotation, and thus accumulates a vast annual tide of air on the northern hemisphere ; and then from June until September, it still continues to draw it northward, although less and less so. But on the twenty-third of September, the Sun begins to draw the aërial tides southward of the equator, and then we have the equinoctial storms, while the Sun is drawing the long accumulated tides of the northern hemisphere over the equator to make a similar accumulation on the southern hemisphere, during the southern summer. On the twenty-first of March, this same cause, having made a similar aërial tide around the South pole, now brings the excess of air Northward again, and then the violent rush of air is another storm of several days continuance. In a perfectly analogous manner, the Moon makes a polar tide on each hemisphere every revolution round the Earth. Now when the Moon is attracting the atmosphere from one circumpolar hemisphere to the other, it is accomplished by a great rush of air, or a violent wind. There being two such occasions every revolution of the Moon, therefore it will occasion such a wind every 13 2-3 days, or about every other occurrence of the day of the week on which it occurs. This is why we so often have all the winds and storms of a season on a certain day of the week. If, in the meantime, the storms that occur from the conjunction of the heavenly bodies fall on the intermediate days, then every time that day of the week occurs, there will be the most or the only stormy days of the season. About the middle of April, 1848, the plane of the Moon's orbit intersected the plane of the equator in a line parallel to where it is crossed by the plane of the Earth's orbit, and during 1849 and 1850, it will not cross the equator more than five degrees from the line of the equinoxes. Hence, this kind of storms will occur for the year 1849 and 1850, immediately after the Moon passes Longitude 1° and also 180°; and the days of the month, on which the Moon passes these points of longitude are mentioned at the bottom of the ephemeris. When the lunar rush of air from pole to pole comes a few days before and after the time of the solar agitation, then the greatest violence of the equinoctial storm is a few days before and a few days after the equinox. But when the lunar and solar currents of air from the poles come on the same days, then the climax of the equinoctial storm comes on very near the equinoxes. Moreover, when these lunar or solar currents of air come at the same time that there is a great rush of air from the combined action of several planets in the same plane of longitude, then the storm will be still more violent and lasting. Indeed, all these causes are continually combined so as to increase or diminish the effects of either one. Again, these various causes of tides and storms are modified by the distance of the planets and the Moon, and by the angle, as to latitude, at which they severally operate. But all these combinations can be exhibited much more conspicuously on the diagram than I can represent them by words. But while the attraction of the Sun, and also the attraction of the Moon are each raising a circumpolar tide on one polar hemisphere, the centrifugal force on account of each of them is at the same time producing another tide at the other pole. Hence, according to this view of the influences of the Moon, its greatest utility to animal life is to agitate and commingle the different strata and regions of the air and water of the Earth, so as to diffuse, or precipitate in rain, all noxious properties that the local causes of any place may produce in the oceans and the atmosphere.

COMETS.

§ 27. Comets revolve round the Sun in every direction, without any regard to the Zodiac in which the planets revolve. They do not appear to be solid bodies, held in a certain form by the attraction of cohesion; but rather as immense clouds of gas, rotating and revolving round the Sun in very eccentric elliptical orbits. The matter of each comet seems to be held together by the mutual attraction of its elements, and the lenticular forms are produced by their rotations. When a comet is very far from the Sun, only its centre or most dense part is visible in the diffused sunlight of a distant region. But as it approaches the Sun and is illuminated by stronger and stronger solar light, then more and more rare regions of the cloud become visible, and thus a comet seems to be immensely larger, the nearer it is to the Sun. The color of comets seems to be modified by the kind of gas of which they are composed. Sometimes they seem composed of various kinds, arranged in layers of different colors, with some portions perfectly transparent so as to show the smallest stars beyond them. More than 500 comets are known, but the time, direction, and form of revolution round the Sun of only a very few are known.

METEOROLOGY.

§ 28. According to the foregoing theory of the tides, the state of the atmosphere, and the conditions of the weather are about as much controlled by the attraction of the Moon as by the heat of the Sun. The aërial tides are indicated by the barometer, and they occur when the general theory indicates they should, rather than when the locally modified ocean tides of the particular place occur. In the high latitudes, the height or weight of the atmosphere is greatest during the months of June and December, when the Earth's axis is most inclined from its radius vector; because the Sun is producing its tides at the greatest distance from the Earth's equator. Analogous tides around high latitudes are also produced twice every sidereal revolution of the Moon; and hence we have a lunar equinoctial wind once every 13 2-3 days. Through January, 1849, the lunar circumpolar aërial tides occur at the time of neap tides, and therefore cause less violent winds than in the following March and April, when they occur at about the same time with the Spring tides. Because these winds are caused by the Moon's moving the protuberance of atmosphere rapidly towards the equator, therefore it may sometimes occur one or two days before the lunar equinox; but usually it attains the greatest velocity on the day of the Moon's crossing the equator. If several planets are in the same plane, so as to raise their greatest tides on the Earth, still there will not be a great wind until the Moon adds its influence to that of the others.

From the same kinds of influences that make the greatest height of the tides occur about three hours after the Moon has passed the meridian, the greatest height of the lunar circumpolar aërial tides are highest about three days after the Moon has revolved through its greatest latitude, and begun to return towards the equator. While the aerial tides are rising, the vapors are also rising, and then we will have clear and calm weather, unless local causes prevent; but while they are falling, the moisture of the air is precipitated, and we have the equinoctial rains. By these immense transmigrations of vast portions of the air, the cold dry atmosphere over one country is conducted to distant regions of the Earth, and exchanged for their warm moist air; or else the contrary may occur, and the warm dry air of one place may be exchanged for the cold damp air of another. By these means, we often have a few days of very warm weather in December, from south winds floating to make a circumpolar tide; and at other times, very cold weather in June, from cold winds rushing from the north to regain their pneumatic equilibrium, about the time the Moon is crossing the equator. From the same causes, we often have the nights warmer than the previous days, because the Moon, in its revolutions, has brought us the warm tropical air; or, on the contrary, we have the days cooler than the previous nights, because the cold northern aërial tides are returning to their equilibrium. Therefore, although the Sun is the grand fountain of the Earth's genial warmth, yet the Moon modifies and diffuses it to the Earth's polar regions, and thereby renders it temperate and habitable, while it cools and tempers the excessive heat of the torrid region.

Day of W.	Day of Mo.	Mercury.	Venus.	Earth.	Moon's Geocentric Longitude.	Mars.	Vesta.	Juno.	Pallas.	Ceres.	Jupiter.	Saturn.	Uranus.	Neptune.
Mo.	1	267	20	101	1	242	23	89	233	241	135	355	21	331·7
Tu.	2	270	22	102	14 ☽	242	.	.	.	.	135	356	21	331·7
W.	3	273	23	103	28	243	.	.	.	.	135	356	21	331·7
Th.	4	276	25	104	43	243	.	.	.	.	135	356	21	331·7
Fr.	5	279	26	105	57	244	24	91	234	242	135	356	21	331·7
Sa.	6	282	28	106	72P.	244	.	.	.	.	135	356	21	331·7
S	7	285	30	107	87	245	.	.	.	.	135	356	21	331·7
Mo.	8	287	31	108	102○	245	.	.	.	.	135	356	21	331·7
Tu.	9	291	33	109	117	246	25	92	235	242	135	356	21	331·7
W.	10	294	34	110	131	246	.	.	.	.	135	356	21	331·7
Th.	11	297	36	111	145	247	.	.	.	.	136	356	21	331·7
Fr.	12	300	38	112	158☊	248	.	.	.	.	136	356	21	331·7
Sa.	13	303	39	113	172	248	26	94	235	243	136	356	21	331·7
S	14	306	41	114	184	249	.	.	.	.	136	356	21	331·7
Mo.	15	310	42	115	197	259	.	.	.	.	136	356	21	331·7
Tu.	16	313	44	116	209 ☾	250	.	.	.	.	136	356	21	331·8
W.	17	317	46	117	221	250	27	95	236	244	136	356	21	331·8
Th.	18	320	47	118	232A.	251	.	.	.	.	136	356	21	331·8
Fr.	19	324	49	119	244	251	.	.	.	.	136	356	21	331·8
Sa.	20	328	50	120	256	252	.	.	.	.	136	356	21	331·8
S	21	332	52	121	268	252	28	96	237	245	136	356	21	331·8
Mo.	22	336	54	122	280	253	.	.	.	.	136	356	21	331·8
Tu.	23	340	55	123	293	254	.	.	.	.	136	356	21	331·8
W.	24	344	57	124	305 ●	254	.	.	.	.	137	356	21	331·8
Th.	25	349	59	125	318	255	29	98	238	246	137	356	21	331·8
Fr.	26	353	60	126	331 ☋	255	.	.	.	.	137	356	21	331·8
Sa.	27	358	62	127	344	255	.	.	.	.	137	356	21	331·8
S	28	3	63	129	358	256	.	.	.	.	137	356	21	331·8
Mo.	29	8	65	130	11	257	30	99	239	247	137	356	21	331·8
Tu.	30	13	67	131	25	257	.	.	.	.	137	356	21	331·8
W.	31	18	68	132	39 ☽	258	.	.	.	.	137	357	21	331·8

APPEARANCE OF THE HEAVENS.

January 1, Earth in Perihelion; ☽ comes N. of the equator; ☽'s ☊ 165½°, and the axis of its orbit inclines towards 75½°; ♃ is S. 2h. 49m. after midnight, and is morning star in Cancer; ♂ in Scorpio, rises a little before the Sun; but ♀ in Capricorn, and ♄ in Aquarius, are evening stars. In the morning Gemini, Canis Major and Canis Minor are setting; but Regulus, ♃, Spica, and the Great Bear are near the meridian; while Scorpio and ♂ are rising. But in the evening, Sagittarius sets soon after the Sun; ♄ and Pisces are near the meridian; and Aldebaran, Pleiades, Orion and the Dog Star are rising. 2, ☽ First Quarter. 8, ○ Full, and ☿ in sup. ☌ ☉. 10, ♃ ☌ ○. 14, ○ goes S. of equator. 16, ☾ Third Quarter. 19, Reäppearance of ♄'s ring. The axis of ♄'s rising inclines up and to the right; but ♄ is now so far S. that it will show only the N. side for several years, until its plane again crosses the Earth's orbit. 21, ♂ ☌ ☾. 24, ● New. 25, Many planets in ☌. 27, ♀ ☌ ●. 28, ♄ ☌ ● and ♀. 29, ♅ ☌ ●. 31, ☽ First Quarter, and comes N. of the equator.

Day of W.	Day of Mo.	Mercury.	Venus.	Earth.	Moon's Geocentric Longitude.	Mars.	Vesta.	Juno.	Pallas.	Ceres.	Jupiter.	Saturn.	Uranus.	Neptune.
Th.	1	24	70	133	53	259	.	.	.	.	137	357	22	331·9
Fr.	2	29	71	134	67	259	31	101	240	247	137	357	22	331·9
Sa.	3	35	73	135	82P.	260	.	.	.	.	137	357	22	331·9
S	4	41	75	136	96	260	.	.	.	.	137	357	22	331·9
Mo.	5	47	76	137	111	261	.	.	.	.	137	357	22	331·9
Tu.	6	53	78	138	125	261	32	102	240	248	138	357	22	331·9
W.	7	59	79	139	139○	262	.	.	.	.	138	357	22	331·9
Th.	8	66	81	140	153	262	.	.	.	.	138	357	22	331·9
Fr.	9	72	83	141	166☊	263	.	.	.	.	138	357	22	331·9
Sa.	10	78	84	142	179	264	33	104	241	249	138	357	22	331·9
S	11	85	86	143	192	264	.	.	.	.	138	357	22	331·9
Mo.	12	91	88	144	204	265	.	.	.	.	138	357	22	331·9
Tu.	13	97	89	145	216	265	.	.	.	.	138	357	22	331·9
W.	14	103	91	146	228☾	266	34	105	242	250	138	357	22	331·9
Th.	15	109	92	147	240A.	266	.	.	.	.	138	357	22	332·0
Fr.	16	115	94	148	252	267	.	.	.	.	138	357	22	332·0
Sa.	17	121	96	149	264	268	.	.	.	.	138	357	22	332·0
S	18	127	97	150	276	268	35	106	243	251	139	357	22	332·0
Mo.	19	132	99	151	289	269	.	.	.	.	139	357	22	332·0
Tu.	20	138	100	152	301	269	.	.	.	.	139	357	22	332·0
W.	21	143	102	153	314	270	.	.	.	.	139	357	22	332·0
Th.	22	148	104	154	327●	270	36	108	244	252	139	367	22	332·0
Fr.	23	153	105	155	340☋	271	.	.	.	.	139	357	22	332·0
Sa.	24	157	107	156	354	272	.	.	.	.	139	357	22	332·0
S	25	162	109	157	8	272	.	.	.	.	139	357	22	332·0
Mo.	26	166	110	158	22	273	37	109	245	252	139	357	22	332·0
Tu.	27	171	112	159	36	273	.	.	.	.	139	357	22	332·0
W.	28	175	113	160	50P.	274	.	.	.	.	139	357	22	332·0

APPEARANCE OF THE HEAVENS.

February 1, ☽'s ☊ 163¼°. 6, ♃ ☍ ☉, and ♃ changes from morning to evening star. 7, ○ Full, and 7 planets in ☌. 8, Mercury visible in the evening. 10, ○ goes south of the equator. 14, ☾ Third Quarter. 22, ● New, and six planets in ☌. To-day, when the Moon is within ten degrees of its ☋, it comes into ☌ with the Sun, and hence is directly between the northern hemispheres of the Sun and Earth. The Moon's southern surface is here about 2000 miles north of the straight line between the centres of the Sun and Earth. Therefore it can only eclipse the northern hemisphere of the Earth. It will be invisible to us, because it will occur about our midnight; yet it may be seen at their noon in the eastern part of Asia, North Pacific Ocean, and in Russian America. This eclipse of the Sun will be central and annular at long. 94° east of Greenwich and lat. 24° north. 24, How long before midnight is ♃ in the meridian? 26, ♀ ☌ ●. On the first, the Moon is in conjunction with Alcyone, the brightest of the 7*s, which is supposed to be the centre around which our Sun revolves and carries its whole planetary system. Hence the Earth has four distinct motions; viz., around its axis, around the Moon, around the Sun, and around the Sun's stellar orbit.

Day of W.	Day of Mo.	Mercury.	Venus.	Earth.	Moon's Geocentric Longitude.	Mars.	Vesta.	Juno.	Pallas.	Ceres.	Jupiter.	Saturn.	Uranus.	Neptune.
Th.	1	179	115	161	64 ☽	274	.	.	.	.	139	357	22	332·1
Fr.	2	183	117	162	78	275	38	110	245	253	139	357	22	332·1
Sa.	3	187	118	163	93	276	.	.	.	.	140	358	22	332·1
S	4	190	120	164	107	276	.	.	.	.	140	358	22	332·1
Mo.	5	194	122	165	121	277	.	.	.	.	140	358	22	332·1
Tu.	6	197	123	166	134	277	39	112	246	254	140	358	22	332·1
W.	7	201	125	167	148	278	.	.	.	.	140	358	22	332·1
Th.	8	204	126	168	161 ○	279	.	.	.	.	140	358	22	332·1
Fr.	9	207	128	169	174	279	.	.	.	.	140	358	22	332·1
Sa.	10	210	130	170	187	280	40	113	247	255	140	358	22	332·1
S	11	214	131	171	200	280	.	.	.	.	140	358	22	332·1
Mo.	12	217	133	172	212	281	.	.	.	.	140	358	22	332·1
Tu.	13	220	135	173	224	282	.	.	.	.	140	358	22	332·1
W.	14	223	136	174	236	282	40	114	248	256	140	358	22	332·1
Th.	15	226	138	175	248 A	283	.	.	.	.	140	358	22	332·2
Fr.	16	229	139	176	260 ☾	283	.	.	.	.	141	358	22	332·2
Sa.	17	231	141	177	272	284	.	.	.	.	141	358	22	382·2
S	18	234	143	178	284	285	41	116	249	256	141	358	22	332·2
Mo.	19	237	144	179	296	285	.	.	.	.	141	358	22	332·2
Tu.	20	240	146	180	309	286	.	.	.	.	141	358	22	332·2
W.	21	243	148	181	322	286	.	.	.	.	141	358	22	332·2
Th.	22	245	149	182	335 ☋	287	42	117	249	257	141	358	22	332·2
Fr.	23	248	151	183	349	288	.	.	.	.	141	358	22	332·2
Sa.	24	251	152	184	3 ●	288	.	.	.	.	141	358	22	332·2
S	25	254	154	185	17	289	.	.	.	.	141	358	22	332·2
Mo.	26	256	156	186	31	289	43	118	250	258	141	358	22	332·2
Tu.	27	259	157	187	46 P.	290	.	.	.	.	141	358	22	332·2
W.	28	262	159	188	61	291	.	.	.	.	141	358	22	332·2
Th.	29	265	161	189	75	291	.	.	.	.	142	358	22	332·2
Fr.	30	267	162	190	89	292	44	119	251	259	142	358	22	332·2
Sa.	31	270	164	191	103 ☽	292	.	.	.	.	142	358	22	332·2

APPEARANCE OF THE HEAVENS.

MARCH 1, ☽ First Quarter, long. ☽'s ☊ 163⅓°, and ♀ greatest elongation E. 46½. In the morning, Virgo is setting and Aquarius is rising, while ♂ is high in the E. But in the evening, Pisces is setting, Gemini and Canis Minor are near the meridian, while Leo and ♃ are rising. 6, Many planets in the same plane of long. 8, ○ Full. From 6 until 9 o'clock this morning, the ○ is in the same plane of heliocentric long. between the Sun and Earth, and a little past its ☊. Then about three fourths of the ○'s disk passes through the Earth's shadow, and appears eclipsed to all parts of the United States. Because it occurs after the moon has come N. of the plane of the Earth's orbit, the earth's shadow passes across the S. part of its disk. 10, ○ goes S. of equator, and ♀ is in Perihelion. 16, ☾ Third Quarter. 20, The Earth passes through the left equinox. 21, Many planets in the same plane of long. 24, ● New, and ● comes N. of equator. 31, ☽ First Quarter. How long before midnight is Regulus in the meridian? How long after midnight is Spica in the meridian?

Day of W.	Day of Mo.	Mercury.	Venus.	Earth.	Moon's Geocentric Longitude	Mars.	Vesta.	Juno.	Pallas.	Ceres.	Jupiter.	Saturn.	Uranus.	Neptune.
S	1	273	165	192	117	293	.	.	.	.	142	358	22	332·3
Mo.	2	276	167	193	131	294	.	.	.	.	142	359	22	332·3
Tu.	3	279	169	194	144	294	45	121	252	260	142	359	22	332·3
W.	4	282	170	195	157 ☋	295	.	.	.	.	142	359	22	332·3
Th.	5	285	172	196	170	295	.	.	.	.	142	359	22	332·3
Fr.	6	288	174	197	183	296	.	.	.	.	142	359	22	332·3
Sa.	7	291	175	198	196 ○	297	46	122	252	260	142	359	22	332·3
S	8	294	177	199	208	297	.	.	.	.	142	359	22	332·3
Mo.	9	297	178	200	220	298	.	.	.	.	142	359	22	332·3
Tu.	10	300	180	200	232	298	.	.	.	.	142	359	22	332·3
W.	11	303	182	201	244	299	47	123	253	261	143	359	22	332·3
Th.	12	307	183	202	256 A.	300	.	.	.		143	359	22	332·3
Fr.	13	310	185	203	268	300	.	.	.	.	143	359	22	332·3
Sa.	14	313	186	204	280	301	.	.	.	.	143	359	22	332·3
S	15	317	188	205	292 ☾	302	48	124	254	262	143	359	22	332·4
Mo.	16	321	190	206	302	302	.	.	.	.	143	359	22	332·4
Tu.	17	324	191	207	316	303	.	.	.	.	143	359	22	332·4
W.	18	328	193	208	330 ☋	303	.	.	.	.	143	359	22	332·4
Th.	19	332	195	209	343	304	49	125	255	263	143	359	22	332·4
Fr.	20	336	196	210	357	305	.	.	.	.	143	359	22	332·4
Sa.	21	340	198	211	11	305	.	.	.	.	143	359	22	332·4
S	22	345	199	212	25 ●	306	.	.	.	.	143	359	22	332·4
Mo.	23	349	201	213	40	307	50	126	256	264	144	359	22	332·4
Tu.	24	354	203	214	55 P.	307	.	.	.	.	144	359	22	332·4
W.	25	358	204	215	70	308	.	.	.	.	144	359	22	332·4
Th.	26	3	206	216	85	308	.	.	.	.	144	359	22	332·4
Fr.	27	8	207	217	100	309	51	128	256	264	144	359	22	332·4
Sa.	28	13	209	218	114	310	.	.	.	.	144	359	22	332·4
S	29	19	211	219	128 ☽	310	.	.	.	.	144	359	22	332·4
Mo.	30	24	212	220	141	311	.	.	.	.	144	359	22	332·4

APPEARANCE OF THE HEAVENS.

April 1, Long. ☽'s ☊ 160¾°. At the commencement of this month, ☿ and ♂ are morning stars, and ♃ and ♀ evening stars, while ♄ is too near the sun to be seen. In the morning ♂ and ☿ in Capricornus rise a little before the sun, while Scorpio is near the meridian, and Virgo is setting. In the evening, Aries is setting, Virgo and Arcturus are rising, but Gemini is near the meridian. At midnight, Gemini is setting, Virgo is near the meridian, and Scorpio is rising. 2, ♃ ☌ ☾. 3, Many globes in the same plane of long. 4, ☿ visible a few mornings. 6, ☽ goes south of equator. 7, ○ Full, and ♀ at greatest brilliancy. 8, ♃ appears stationary, and ☿ ☌ ♄. 15, ☾ Third Quarter. 20, ☾ comes north of equator, ♀ appears stationary, and ♄ ☌ ☾. 22. ● New. 29, ☽ First Quarter. How many degrees does Jupiter seem geocentrically to have retrograded or gone back among the stars since the commencement of this year? Ans. 10°. In what geocentric longitude will Jupiter be at the end of this year? Ans. 174°, or very near Virgo.

Day of W.	Day of Mo.	Mercury.	Venus.	Earth.	Moon's Geocentric Longitude.	Mars.	Vesta.	Juno.	Pallas.	Ceres.	Jupiter.	Saturn.	Uranus.	Neptune.
Tu.	1	30	214	221	154☊	312	52	129	257	265	144	360	22	332·5
W.	2	35	215	222	167	312	.	.	.	.	144	360	22	332·5
Th.	3	41	217	223	180	313	.	.	.	.	144	360	22	332·5
Fr.	4	47	219	224	192	313	.	.	.	.	144	360	23	332·5
Sa.	5	53	220	225	205	314	53	130	258	266	144	360	23	332·5
S	6	60	222	226	217	315	.	.	.	.	145	360	23	332·5
Mo.	7	66	223	227	229○	315	.	.	.	.	145	360	23	332·5
Tu.	8	72	225	228	241	316	.	.	.	.	145	360	23	332·5
W.	9	78	227	229	253A.	317	53	131	259	267	145	360	23	332·5
Th.	10	85	228	230	265	317	.	.	.	.	145	360	23	332·5
Fr.	11	91	230	231	277	318	.	.	.	.	145	360	23	332·5
Sa.	12	97	231	232	289	318	.	.	.	.	145	360	23	332·5
S	13	103	233	233	301	319	54	132	259	268	145	360	23	332·5
Mo.	14	109	235	234	313	320	.	.	.	.	145	360	23	332·5
Tu.	15	115	236	234	325☾	320	.	.	.	.	145	360	23	332·6
W.	16	121	238	235	338☋	321	.	.	.	.	145	360	23	332·6
Th.	17	127	239	236	351	322	55	133	260	268	145	360	23	332·6
Fr.	18	132	241	237	5	322	.	.	.	.	145	360	23	332·6
Sa.	19	138	243	238	19	323	.	.	.	.	146	360	23	332·6
S	20	143	244	239	34	324	.	.	.	.	146	360	23	332·6
Mo.	21	148	246	240	49	324	56	134	261	269	146	360	23	332·6
Tu.	22	153	247	241	64●	325	.	.	.	.	146	360	23	332·6
W.	23	158	249	242	79	325	.	.	.	.	146	360	23	332·6
Th.	24	162	251	243	94	326	.	.	.	.	146	360	23	332·6
Fr.	25	167	252	244	109	327	57	135	262	270	146	360	23	332·6
Sa.	26	171	254	245	124	327	.	.	.	.	146	360	23	332·6
S	27	175	255	246	138	328	.	.	.	.	146	360	23	332·6
Mo.	28	179	257	247	151☊	329	.	.	.	.	146	360	23	332·6
Tu.	29	183	258	248	164	329	58	137	262	271	146	360	23	332·6
W.	30	187	260	249	177	330	.	.	.	.	146	360	23	332·6
Th.	31	190	262	250	190	331	.	.	.	.	146	1	23	332·6

APPEARANCE OF THE HEAVENS.

May 1, During this month, ☿ and ♀ are geocentrically so near the same long. with the Sun, that they are scarcely visible; Jupiter will be evening star, but Mars and Saturn morning stars. Jupiter seems in the constellation Cancer, Mars and Saturn in Aquarius, with Venus and Mercury near the Sun in Aries. In the morning, Pisces is rising, Capricornus is S., and Libra is setting. In the evening, Taurus is setting, Jupiter and Cancer are near the meridian, with Virgo rising. But at midnight Libra is on the meridian, Cancer W., and Capricornus E. 3, ☽ goes S. of equator. 6, Many globes in the same plane of long. 7, ○ Full. 12, ♀ ☌ ☉ Although Venus is in conjunction with the Sun to-day, there will not be a transit of Venus across the Sun's disk, because Venus is now so far from its descending node, that it is more than a million miles north or in front of the plane of the Earth's orbit. 15, ☾ Third Quarter. 18, ☾ comes N. of equator. 21, Many globes in the same plane of long. 22, ● New. 27, ♀ in ☋. 28, ☽ First Quarter. 31. ☽ goes S. of equator.

Day of W.	Day of Mo.	Mercury.	Venus.	Earth.	Moon's Geocentric Longitude.	Mars.	Vesta.	Juno.	Pallas.	Ceres.	Jupiter.	Saturn.	Uranus.	Neptune.
Fr.	1	194	263	251	202	331	.	.	.	.	147	1	23	332·7
Sa.	2	197	265	252	214	332	59	138	263	272	147	1	23	332·7
S	3	201	266	253	226	332	.	.	.	.	147	1	23	332·7
Mo.	4	204	268	254	238	333	.	.	.	.	147	1	23	332·7
Tu.	5	207	270	255	250○	334	.	.	.	.	147	1	23	332·7
W.	6	211	271	256	262A.	334	60	139	264	272	147	1	23	332·7
Th.	7	214	273	257	274	335	.	.	.	.	147	1	23	332·7
Fr.	8	217	274	258	286	336	.	.	.	.	147	1	23	332·7
Sa.	9	220	276	258	298	336	.	.	.	.	147	1	23	332·7
S	10	223	277	259	310	337	61	140	265	273	147	1	23	332·7
Mo.	11	226	279	260	322	338	.	.	.	.	147	1	23	332·7
Tu.	12	229	281	261	334☋	338	.	.	.	.	147	1	23	332·7
W.	13	232	282	262	347☾	339	.	.	.	.	147	1	23	332·7
Th.	14	234	284	263	360	339	62	141	265	274	148	1	23	332·7
Fr.	15	237	285	264	14	340	.	.	.	.	148	1	23	332·8
Sa.	16	240	287	265	28	341	.	.	.	.	148	1	23	332·8
S	17	243	289	266	42	341	.	.	.	.	148	1	23	332·8
Mo.	18	246	290	267	57	342	63	142	266	275	148	1	23	332·8
Tu.	19	248	292	268	72P.	343	.	.	.	.	148	1	23	332·8
W.	20	251	293	269	88●	343	.	.	.	.	148	1	23	332·8
Th.	21	254	295	270	103	344	.	.	.	.	148	1	23	332·8
Fr.	22	257	296	271	118	344	64	143	267	275	148	1	23	332·8
Sa.	23	259	298	272	132	345	.	.	.	.	148	1	23	332·8
S	24	262	300	273	147	346	.	.	.	.	148	1	23	332·8
Mo.	25	265	301	274	160☊	346	.	.	.	.	148	1	23	332·8
Tu.	26	268	303	275	173	347	64	144	268	276	148	1	23	332·8
W.	27	270	304	276	186☽	348	.	.	.	.	149	1	23	332·8
Th.	28	273	306	277	199	348	.	.	.	.	149	1	23	332·8
Fr.	29	276	308	278	211	349	.	.	.	.	149	1	23	332·8
Sa.	30	279	309	278	223	350	65	145	268	277	149	2	23	332·8

APPEARANCE OF THE HEAVENS.

June 1, Long. ☽'s ☊ 157½°. Many globes in the same plane of long. ♀ appears stationary in Aries, because for several days it seems in the same part of that constellation. ♀ ♂ and ♄ are morning stars, but ♃ and ☿ are evening stars. In the morning, Aries is rising, Aquarius is S., and Sagittarius is setting. In the evening, Gemini is setting, Leo S., and Scorpio is rising. But at midnight, Scorpio is S., Aquarius near the eastern horizon, and Virgo just going behind the western horizon. Mars appears geocentrically in Pisces, and Mercury in Gemini. On account of the long and bright twilight, Mercury will scarcely be visible this month. 4, Many globes in the same plane of long., and ♂ in Perihelion. 5, ○ Full. 13, ☾ Third Quarter. 14, ☾ comes N. of equator; mean clock and solar time agree, and ♄ ☌ ☾. 15, ♂ ☌ ☾. 18, ♀ greatest brilliancy. How long after midnight will ♀ be in the meridian? 20, ● New. 21, greatest variation of the Earth's axis from the radius vector. 24, ● ☌ Regulus. 27, ☽ First Quarter, and ☽ goes S. of equator.

Day of W.	Day of Mo.	Mercury.	Venus.	Earth.	Moon's Geocentric Longitude.	Mars.	Vesta.	Juno.	Pallas.	Ceres.	Jupiter.	Saturn.	Uranus.	Neptune.
S	1	282	311	279	235	350	.	.	.	.	149	2	23	333·9
Mo.	2	285	312	280	247	351	.	.	.	.	149	2	23	333·9
Tu.	3	288	314	281	259A.	351	.	.	.	.	149	2	23	333·9
W.	4	291	315	282	271	352	66	146	269	278	149	2	23	333·9
Th.	5	294	317	283	283○	353	.	.	.	.	149	2	23	333·9
Fr.	6	297	319	284	295	353	.	.	.	.	149	2	23	333·9
Sa.	7	300	320	285	307	354	.	.	.	.	149	2	23	333·9
S	8	303	322	286	319	355	67	147	270	278	149	2	23	333·9
Mo.	9	307	323	287	331☋	355	.	.	.	.	150	2	23	333·9
Tu.	10	310	325	288	344	356	.	.	.	.	150	2	23	333·9
W.	11	313	327	289	357	356	.	.	.	.	150	2	23	333·9
Th.	12	317	328	290	10	357	68	148	271	279	150	2	23	333·9
Fr.	13	321	330	291	23 ☾	358	.	.	.	.	150	2	23	333·9
Sa.	14	324	331	292	37	358	.	.	.	.	150	2	23	333·9
S	15	328	333	293	52	359	.	.	.	.	150	2	23	333·9
Mo.	16	332	334	294	66	360	69	149	271	280	150	2	23	333·9
Tu.	17	336	336	295	81	360	.	.	.	.	150	2	23	333·9
W.	18	340	338	296	96P.	1	.	.	.	.	150	2	23	333·9
Th.	19	345	339	297	111●	1	.	.	.	.	150	2	23	333·9
Fr.	20	349	341	298	126	2	70	150	272	281	150	2	23	333·0
Sa.	21	354	342	299	141☊	3	.	.	.	.	150	2	23	333·0
S	22	358	344	299	155	3	.	.	.	.	151	2	23	333·0
Mo.	23	3	346	300	169	4	.	.	.	.	151	2	23	333·0
Tu.	24	8	347	301	182	5	71	150	273	282	151	2	23	333·0
W.	25	13	348	302	195	5	.	.	.	.	151	2	23	333·0
Th.	26	19	350	303	207 ☽	6	.	.	.	.	151	2	23	333·0
Fr.	27	24	352	304	220	6	.	.	.	.	151	2	23	333·0
Sa.	28	30	353	305	232	7	72	151	273	282	151	2	23	333·0
S	29	36	355	306	244	8	.	.	.	.	151	3	23	333·0
Mo.	30	41	357	307	255A.	8	.	.	.	.	151	3	23	333·0
Tu.	31	47	358	308	267	9	.	.	.	.	151	3	23	333·0

APPEARANCE OF THE HEAVENS.

July 1, Earth in Aphelion. In the morning, Taurus is near the eastern horizon, Pisces near the meridian, and Capricornus near the western horizon. In the evening, Jupiter and Cancer are near the western horizon, Virgo near the meridian, and Scorpio near the western horizon. But at midnight, Sagittarius is near the meridian, with Aquarius and Saturn near the eastern, and Virgo near the western horizon. 5, ○ Full, and many planets in the same plane of long. 12, ○ comes N. of equator, and ♄ ☌ ○. 13, ☾ Third Quarter, and ♅ ☌ ☾. 14, ♂ ☌ ☾, 16, ♀ ☌ *a* Tauri and ☾. 19, ● New. 20, Many planets in the same plane of long., and ♄ appears stationary in Pisces. 21, ♃ ☌ ●, and ● ☌ Regulus. 22, ♀ greatest elongation west. 23, ♀ fartherest south four million miles. 24, ● goes south of equator. 26, ☽ First Quarter.

EPHEMERIS FOR AUGUST, 1849.

Day of W.	Day of Mo.	Mercury.	Venus.	Earth.	Moon's Geocentric Longitude.	Mars.	Vesta.	Juno.	Pallas.	Ceres.	Jupiter.	Saturn.	Uranus.	Neptune.
W.	1	54	360	309	279	9	73	152	274	283	151	3	23	333·0
Th.	2	60	1	310	291	10	.	.	.	.	151	3	23	333·0
Fr.	3	66	3	311	303○	11	.	.	.	.	151	3	23	333·0
Sa.	4	72	5	312	316	11	.	.	.	.	152	3	24	333·0
S	5	79	6	313	328☋	12	74	153	275	284	152	3	24	333·0
Mo.	6	85	8	314	341	13	.	.	.	.	152	3	24	333·0
Tu.	7	91	9	315	354	13	.	.	.	.	152	3	24	333·0
W.	8	97	11	316	7	14	.	.	.	.	152	3	24	333·0
Th.	9	104	13	317	20	14	74	154	275	285	152	3	24	333·0
Fr.	10	110	14	318	34	15	.	.	.	.	152	3	24	333·0
Sa.	11	116	16	319	48☾	16	.	.	.	.	152	3	24	333·0
S	12	121	17	320	62	16	.	.	.	.	152	3	24	333·0
Mo.	13	127	19	321	76	17	75	155	276	285	152	3	24	333·0
Tu.	14	133	21	322	91	17	.	.	.	.	152	3	24	333·0
W.	15	138	22	322	105P.	18	.	.	.	.	152	3	24	333·0
Th	16	143	24	323	120	19	.	.	.	.	152	3	24	333·0
Fr.	17	148	25	324	135	19	76	156	277	286	153	3	24	333·0
Sa.	18	153	27	325	149●☊	20	.	.	.	.	153	3	24	333·0
S	19	158	29	326	163	20	.	.	.	.	153	3	24	333·0
Mo.	20	162	30	327	177	21	.	.	.	.	153	3	24	333·0
Tu.	21	167	32	328	190	22	77	157	278	287	153	3	24	333·0
W.	22	171	33	329	203	22	.	.	.	.	153	3	24	333·0
Th.	23	175	35	330	215	23	.	.	.	.	153	3	24	333·0
Fr.	24	179	37	331	228	23	.	.	.	.	153	3	24	333·0
Sa.	25	183	38	332	240☽	24	78	158	278	288	153	3	24	333·0
S	26	187	40	333	252	25	.	.	.	.	153	3	24	333·0
Mo.	27	190	41	334	264A.	25	.	.	.	.	153	3	24	333·0
Tu.	28	194	43	335	276	26	.	.	.	.	153	4	24	333·0
W.	29	198	45	336	288	26	79	159	279	288	153	4	24	333·0
Th.	30	201	46	337	300	27	.	.	.	.	154	4	24	333·0
Fr.	31	204	48	338	312	28	.	.	.	.	154	4	24	333·0

APPEARANCE OF THE HEAVENS.

August 1, Long. of ☽'s ☊ 154⅓°. ☿, ♀, ♂ and ♄ are morning stars; but ♃ sets soon after the Sun. How long from midnight is each of them in the meridian? And in what constellation does each of them appear? 3, ○ Full. 5, Many globes in the same plane of long. 8, ○ comes N. of equator, and ♄ ☌ ○. 11, ☾ Third Quarter, and ♂ ☌ ☾. 14, ♀ ☌ ☾. 18, ♃ ☌ ●; ● New, and eclipses the sun. At about one o'clock, A. M., the Sun, Moon and Earth are in the same plane of long., and the moon is then coming northward, and is within eight degrees of entering the plane of the Earth's orbit, to pass through its ascending node. The northern surface of the Moon is then about 1500 miles south of the plane of the Earth's orbit. Because the moon is then between the southern parts of the Sun and Earth, this eclipse of the Sun is central and total at the noon at 90° E. long. from Greenwich, and 36° S.lat. 21, ● goes S. of equator. 25, ☽ First Quarter. 26, ♃ ☌ ☉, but ten million miles north of the plane of the Earth's orbit. 31 Mean clock and meridian solar time agree.

Day of W.	Day of Mo.	Mercury.	Venus.	Earth.	Moon's Geocentric Longitude.	Mars.	Vesta.	Juno.	Pallas.	Ceres.	Jupiter.	Saturn.	Uranus.	Neptune.
Sa.	1	207	49	339	325	28	.	.	.	.	154	4	24	333·1
S	2	211	51	340	337○☊	29	80	159	280	289	154	4	24	333·1
Mo.	3	214	53	341	350	29	.	.	.	.	154	4	24	333·1
Tu.	4	217	54	342	4	30	.	.	.	.	154	4	24	333·1
W.	5	220	56	343	17	30	.	.	.	.	154	4	24	333·1
Th.	6	223	57	344	31	31	81	160	281	290	154	4	24	333·1
Fr.	7	226	59	345	45	32	.	.	.	.	154	4	24	333·1
Sa.	8	229	61	346	59	32	.	.	.	.	154	4	24	333·1
S	9	232	62	347	73 ☾	33	.	.	.	.	154	4	24	333·1
Mo.	10	234	64	348	87	33	82	161	281	291	154	4	24	333·1
Tu.	11	237	65	349	101P.	34	.	.	.	.	154	4	24	333·1
W.	12	240	67	350	116	35	.	.	.	.	155	4	24	333·1
Th.	13	243	69	351	130	35	.	.	.	.	155	4	24	333·1
Fr.	14	246	70	352	144☊	36	83	162	282	291	155	4	24	333·1
Sa.	15	248	72	352	158	36	.	.	.	.	155	4	24	333·1
S	16	251	73	353	171●	37	.	.	.	.	155	4	24	333·1
Mo.	17	254	75	354	185	37	.	.	.	.	155	4	24	333·1
Tu.	18	257	77	355	198	38	84	163	282	292	155	4	24	333·1
W.	19	259	78	256	211	39	.	.	.	.	155	4	24	333·1
Th.	20	262	80	357	223	39	.	.	.	.	155	4	24	333·1
Fr.	21	265	82	358	236	40	.	.	.	.	155	4	24	333·1
Sa.	22	268	83	359	248	40	84	164	283	293	155	4	24	333·1
S	23	270	85	360	260	41	.	.	.	.	155	4	24	333·1
Mo.	24	273	86	1	272A. ☽	41	.	.	.	.	155	4	24	333·1
Tu.	25	276	88	2	283	42	.	.	.	.	156	4	24	333·1
W.	26	279	90	3	295	43	85	164	284	294	156	4	24	333·1
Th.	27	282	91	4	308	43	.	.	.	.	156	5	24	333·1
Fr.	28	285	93	5	320	44	.	.	.	.	156	5	24	333·1
Sa.	29	288	94	6	333☋	44	.	.	.	.	156	5	24	333·1
S	30	291	96	7	346	45	86	165	284	294	156	5	24	333·1

APPEARANCE OF THE HEAVENS.

SEPTEMBER 1, Long. ☽'s ☊ 152⅗°. In the morning, Cancer is rising, and Aquarius is setting, while ♀, ♂ and Aries are near the meridian. But in the evening, Virgo is setting, Aquarius rising, with Scorpio near the meridian. ♀, ♂, ♃ and ♄ are morning stars, but ♃ and ☿ are so near the Sun as to be invisible. In what constellation is ♂? ♄? ☿? ♀? How long before midnight will Fomalhaut be in the meridian? How long before the Sun will Regulus rise? 2, ○ Full. A few degrees after the moon has passed its descending node, it comes into the same plane of longitude with the Sun and Earth. Then six tenths of the northern part of its surface passes through the earth's shadow; while the southern four tenths of its diameter continues to be luminous. 4, ○ comes north of equator. 9, ☾ Third Quarter. 16, ● New, and many globes in the same plane of long. 17, ● goes south of equator. 23, The Earth's axis is perpendicular to its radius vector, and the days and nights are of equal length throughout the earth. 24, ☽ First Quarter. 25, ☿ visible for a few evenings.

EPHEMERIS FOR OCTOBER, 1849.

Day of W.	Day of Mo.	Mercury.	Venus.	Earth.	Moon's Geocentric Longitude.	Mars.	Vesta.	Juno.	Pallas.	Ceres.	Jupiter.	Saturn.	Uranus.	Neptune.
Mo.	1	294	98	8	359	45	.	.	.	.	156	5	24	333·2
Tu.	2	297	99	9	13○	46	.	.	.	.	156	5	24	333·2
W.	3	300	101	10	27	47	.	.	.	.	156	5	24	333·2
Th.	4	303	103	11	41	47	87	166	285	295	156	5	24	333·2
Fr.	5	307	104	12	55	48	.	.	.	.	156	5	24	333·2
Sa.	6	310	106	13	69P.	48	.	.	.	.	156	5	24	333·2
S	7	314	107	14	84	49	.	.	.	.	156	5	24	333·2
Mo.	8	317	109	15	98☾	49	88	167	286	296	157	5	24	333·2
Tu.	9	321	111	16	112	50	.	.	.	.	157	5	24	333·2
W.	10	325	112	17	126	50	.	.	.	.	157	5	24	333·2
Th.	11	328	114	18	140	51	.	.	.	.	157	5	24	333·2
Fr.	12	332	116	19	154☊	52	89	168	286	297	157	5	24	333·2
Sa.	13	336	117	20	167	52	.	.	.	.	157	5	24	333·2
S	14	341	119	21	180	53	.	.	.	.	157	5	24	333·2
Mo.	15	345	120	22	193	53	.	.	.	.	157	5	24	333·2
Tu.	16	349	122	23	206●	54	90	168	287	297	157	5	24	333·2
W.	17	354	124	24	219	54	.	.	.	.	157	5	24	333·2
Th.	18	359	125	25	231	55	.	.	.	.	157	5	24	333·2
Fr.	19	3	127	26	244	55	.	.	.	.	157	5	24	333·2
Sa.	20	8	129	27	256	56	91	169	287	298	157	5	24	333·2
S	21	14	130	28	268A.	56	.	.	.	.	158	5	24	333·2
Mo.	22	19	132	29	279	57	.	.	.	.	158	6	24	333·2
Tu.	23	24	133	30	291	58	.	.	.	.	158	5	24	333·2
W.	24	30	135	31	303☽	58	92	170	288	299	158	5	24	333·2
Th.	25	36	137	32	315	59	.	.	.	.	158	5	24	333·2
Fr.	26	42	138	33	328☋	59	.	.	.	.	158	6	24	333·2
Sa.	27	48	140	34	340	60	.	.	.	.	158	6	24	333·2
S	28	54	142	35	353	60	93	171	289	300	158	6	24	333·2
Mo.	29	60	143	35	7	61	.	.	.	.	158	6	24	333·2
Tu.	30	66	145	37	22	61	.	.	.	.	158	6	24	333·2
W.	31	73	146	38	35○	62	.	.	.	.	158	6	24	333·2

APPEARANCE OF THE HEAVENS.

October 1, Jupiter rises about two hours before the Sun, while Saturn and the moon rise about sunset, and are on the meridian at midnight. ♃, ♀ and ♂ are morning stars, while ☿ and ♄ are evening stars. Saturn seems retrograding, because the earth revolves so much faster than it, that ♄ is left behind. To-day, the ☽ comes N. of equator. 2, ○ Full. 8, ☾ Third Quarter. On the 9th, ☿ is in Libra, but on the 28th instant it seems to have retrograded into Virgo, by revolving faster than the Earth and between the Earth and Sun. There will not be a transit of ☿ across the Sun's disk, on the 24th inst., because ☿ is a million miles south of the plane of the Earth's orbit. 13, Many planets in ☌. 14, ☾ goes south of equator. 16, ● New, and many globes in ☌. 31, ○ Full, Towards which line of long. does the north pole of each of the planets incline? (See Table of Dimensions.) Their equinoxes are 90° from that line. Where are the equinoxes of ♀? ♂? ♄?

Day of W.	Day of Mo.	Mercury.	Venus.	Earth.	Moon's Geocentric Longitude.	Mars.	Vesta.	Juno.	Pallas.	Ceres.	Jupiter.	Saturn.	Uranus.	Neptune.
Th.	1	79	148	39	50	62	94	171	289	300	158	6	24	333·3
Fr.	2	85	150	40	65P.	63	.	.	.	.	158	6	24	333·3
Sa.	3	91	151	41	80	63	.	.	.	.	159	6	24	333·3
S	4	98	153	42	94	64	.	.	.	.	159	6	25	333·3
Mo.	5	104	155	43	109	64	95	172	290	301	159	6	25	333·3
Tu.	6	110	156	44	123	65	.	.	.	.	159	6	25	333·3
W.	7	116	158	45	137 ☾	66	.	.	.	.	159	6	25	333·3
Th.	8	122	159	46	151 ☋	66	.	.	.	.	159	6	25	333·3
Fr.	9	127	161	47	164	67	95	173	281	302	159	6	25	333·3
Sa.	10	133	163	48	177	67	.	.	.	.	159	6	25	333·3
S	11	138	164	49	190	68	.	.	.	.	159	6	25	333·3
Mo.	12	143	166	50	203	68	.	.	.	.	159	6	25	333·3
Tu.	13	148	168	51	215	69	96	174	291	303	159	6	25	333·3
W.	14	153	169	52	228 ●	69	.	.	.	.	159	6	25	333·3
Th.	15	158	171	53	240	70	.	.	.	.	159	6	25	333·4
Fr.	16	162	172	54	252	70	.	.	.	.	160	6	25	333·4
Sa.	17	167	174	55	264	71	97	174	292	203	160	6	25	333·4
S	18	171	176	56	276A.	71	.	.	.	.	160	6	25	333·4
Mo.	19	175	177	57	288	72	.	.	.	.	160	6	25	333·4
Tu.	20	179	179	58	300	72	.	.	.	.	160	6	25	333·4
W.	21	183	181	59	311	73	98	175	292	304	160	6	25	333·4
Th.	22	187	182	60	323 ☽	73	.	.	.	.	160	6	25	333·4
Fr.	23	191	184	61	336	74	.	.	.	.	160	6	25	333·4
Sa.	24	194	185	62	348	74	.	.	.	.	160	7	25	333·4
S	25	198	187	63	1	75	99	176	293	305	160	7	25	333·4
Mo.	26	201	189	64	15	75	.	.	.	.	160	7	25	333·4
Tu.	27	204	190	65	29	76	.	.	.	.	160	7	25	333·4
W.	28	208	192	66	43	76	.	.	.	.	160	7	25	333·4
Th.	29	211	193	67	58 ○	77	100	177	294	306	161	7	25	333·4
Fr.	30	214	195	68	73P.	77	.	.	.	.	161	7	25	333·4

APPEARANCE OF THE HEAVENS.

November 1, ☿, ♀, and ♃ in the east, and ♂ in the west, are morning stars; while ♄ may be seen retrograding in the evening near the western horizon. Virgo rises a little before the Sun, while Aries is setting, and Cancer is near the meridian. In the evening, Scorpio sets soon after the Sun, while Capricornus is near the meridian, and the Moon and Aries are rising. At midnight, Aries is near the meridian, with Cancer in the east and Capricornus in the west. 3, Mean clock time 16m. 17s. later than solar meridian time. 7, ☾ Third Quarter. 9, ♂ retrogrades, from to-day, until after the end of this year, in the constellations Gemini and Taurus. 11, ☾ goes south of equator. 14, ● New. 22, ☽ First Quarter. 25, ☽ comes north of equator. 29, ○ Full. 30, Many globes in the same plane of longitude. How long before the Sun will ♀ rise on the first of this month? On the last of the month? How many hours high will ♃ be at midnight on the first and also on the last mornings of this month?

Day of W.	Day of Mo.	Mercury.	Venus.	Earth.	Moon's Geocentric Longitude.	Mars.	Vesta.	Juno.	Pallas.	Ceres.	Jupiter.	Saturn.	Uranus.	Neptune.
Sa.	1	217	197	69	99	78	.	.	.	.	161	7	25	333·5
S	2	220	198	70	104	78	.	.	.	.	161	7	25	333·5
Mo.	3	223	200	71	118	79	101	177	294	306	161	7	25	333·5
Tu.	4	226	201	72	133 ☊	79	.	.	.	.	161	7	25	333·5
W.	5	229	203	73	147	80	.	.	.	.	161	7	25	333·5
Th.	6	232	205	74	161 ☾	80	.	.	.	.	161	7	25	333·5
Fr.	7	235	206	75	174	81	102	178	295	307	161	7	25	333·5
Sa.	8	237	208	76	187	81	.	.	.	.	161	7	25	333·5
S	9	240	210	77	200	82	.	.	.	.	161	7	25	333·5
Mo.	10	243	211	78	212	82	.	.	.	.	161	7	25	333·5
Tu.	11	246	213	79	225	83	103	179	295	308	161	7	25	333·5
W.	12	248	214	80	237	83	.	.	.	.	162	7	25	333·5
Th.	13	251	216	81	249	84	.	.	.	.	162	7	25	333·5
Fr.	14	254	218	82	261 ●	84	.	.	.	.	162	7	25	333·5
Sa.	15	257	219	83	273	85	104	180	296	309	162	7	25	333·5
S	16	259	221	84	285 A.	85	.	.	.	.	162	7	25	333·5
Mo.	17	262	222	86	296	86	.	.	.	.	162	7	25	333·5
Tu.	18	265	224	87	308	86	.	.	.	.	162	7	25	333·5
W.	19	268	226	88	320 ☋	87	105	180	297	309	162	7	25	333·5
Th.	20	271	227	89	332	87	.	.	.	.	162	7	25	333·5
Fr.	21	273	229	90	344	88	.	.	.	.	162	7	25	333·5
Sa.	22	276	230	91	357 ☽	88	.	.	.	.	162	7	25	333·5
S	23	279	232	92	10	89	106	181	297	310	162	7	25	333·5
Mo.	24	282	234	93	23	89	.	.	.	.	162	8	25	333·5
Tu.	25	285	235	94	37	90	.	.	.	.	163	8	25	333·5
W.	26	288	237	95	51	90	.	.	.	.	163	8	25	333·5
Th.	27	291	238	96	66	91	107	182	298	311	163	8	25	333·5
Fr.	28	294	240	97	81	91	.	.	.	.	163	8	25	333·5
Sa.	29	297	242	98	97 ○	92	.	.	.	.	163	8	25	333·5
S	30	300	243	99	112	92	.	.	.	.	163	8	25	333·5
Mo.	31	304	245	100	127	93	108	182	298	312	163	8	25	333·5

APPEARANCE OF THE HEAVENS.

DECEMBER 1, Long. ○'s ☊ 148°. Geocentrically ♀ appears in Libra, ♃ in Leo, and ♂ in Gemini. ♂ continues retrograding. ♀, ♂ and ♃ are morning stars, while ♄ in Pisces is evening star. In the morning, Libra rises a little before the Sun; with Leo near the meridian, and Gemini near the western horizon. What constellation is on the meridian at midnight? 5, ♄ ceases retrograding, and is now stationary, but will soon seem to advance. Moon eclipses Regulus. 6, ☾ Third Quarter. 7, ☾ eclipses ♃. 8, ☾ goes south of equator. 14, ● New, and many globes in the same plane of long. 18, ♂ on the meridian at midnight. 21, Earth's axis most inclined to its radius vector. 22, ☽ First Quarter. 23, ☽ comes north of equator. 25, Mean and solar time agree. 29, ○ Full. 31, Earth in perihelion. Why did not Mars have the Earth between it and the Sun on the 18th inst.? Ans. Because Mars was then three million miles north of the plane of the Earth's orbit.

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