961. *Transits.*—The passage of an inferior planet across the Sun's disk is called its Transit. In Fig. 333, Venus at V is making her transit.

A transit can take place only when a planet is in inferior conjunction. But, as the orbits of the planets are in different planes, there may be inferior conjunctions without any transit. Venus may be seen from the Earth in the same quarter as the Sun, and yet lie out of the plane which connects the centres of the Sun and the Earth.

962. *Occultation.*—When a planet or star is hid from the view of an observer on the Earth by the interposition of some other heavenly body, it is said *to suffer occultation.*

963. Real and Apparent Motions.—An observer at the Sun would see all the planets moving around him from west to east with perfect regularity and always in the same direction. He would see their Real Motions. An observer on the Earth sees only their Apparent Motions, and these are so irregular that one might almost fancy the bodies in question wandering through space without any fixed law to direct their course. They are seen at one time moving from west to east, at another stationary, and again pursuing a retrograde course from east to west.

The reasons of this are—1. We are 95,000,000 miles from their centre of motion. 2. We are ourselves moving, both round the sun and round the Earth's axis. Unconscious of these motions, we intuitively attribute the changes of direction produced by them to the motions of the orbs around us; just as a person on a boat, when it begins to move, seems to be at rest himself, and to see the wharf receding from him.

964. Are the Heavenly Bodies inhabited?—This question is often asked, but can not be answered. No evidences of inhabitants have ever been discovered, even in the Moon, which is the nearest to us of all the heavenly bodies; nor can there be any till great improvements have been made in the telescope. Nothing, however, seems to be created without an object; and, humanly speaking, it would be strange if of all the orbs which Omnipotence has

by a Transit? Show the difference between a transit and inferior conjunction. 962. When is a planet or star said to suffer occultation? 963. What is the difference between the Real and the Apparent Motions of the planets? Describe the apparent motions. What causes are assigned for their irregularity? 964. What is said with

called into being our little world were the only one peopled by intelligent creatures.

If the planets are inhabited, it must be by creatures constituted very differently from the human race. Surrounded by entirely different circumstances as regards temperature, gravity, atmosphere, &c., the inhabitants of the different planets must be distinct races each from every other. Yet who can doubt that the same Infinite Wisdom that has adapted us to our sphere could as easily adapt them to theirs?

We proceed to consider the planets in turn. The character annexed to the name is the mark by which the planet is denoted.

965. Mercury (☿).—The nearest planet to the Sun is Mercury. Under favorable circumstances, Mercury may be seen at certain times of the year for a few minutes after sun-set or before sun-rise. At other times it keeps so close to the Sun as to be invisible, being lost in the superior brightness of his rays in the daytime, and setting and rising so nearly at the same time with him as to afford no opportunity of observation.

To the naked eye Mercury looks like a star of the third magnitude, twinkling (unlike the other planets) with a pale rosy light. Viewed through the telescope, it exhibits similar phases or changes of appearance to those of the moon (from full to new); this is because we see more of its enlightened side at one time than another.

The solar heat received at Mercury is seven times as great as that of the Earth,—a temperature more than sufficient to make water boil. Mercury's light is also seven times as intense as ours, and the Sun seen from this planet would look seven times as large as it does to us. No permanent spots are visible either on Mercury or Venus, whence it has been supposed that we do not see the surfaces of these planets, but only their atmospheres loaded with clouds, which may serve to mitigate the otherwise intense glare of the sun. A German astronomer, however, at the commencement of the present century, observed what he regarded as a number of mountains on the surface of Mercury, one of which he computed to be over 10 miles in height.

respect to the heavenly bodies' being inhabited? 965. What is the nearest planet to the Sun? When is Mercury visible? What makes it invisible at other times? How does Mercury look to the naked eye? Viewed through the telescope, what phases does it present? How do the solar heat and light received at Mercury compare with ours? Are any permanent spots visible on Mercury or Venus? To what supposition has this fact led? What was observed on Mercury by a German astronomer?

Mercury's orbit deviates from a circle much more than that of any other planet, the asteroids excepted. This circumstance, combined with the inclination of its axis to the plane of its orbit, must produce a great variety of seasons, and extreme changes of temperature.

966. Venus (♀).—The second planet from the Sun is Venus. On account of its nearness, it appears larger and more beautiful to us than any other member of our planetary system. So bright is Venus that it is sometimes visible at mid-day to the naked eye, and in the absence of the Moon casts a perceptible shadow.

Being an inferior planet, Venus is never in opposition to the sun, and is always below the horizon at midnight. During part of the year, it rises before the Sun, and ushers in, as it were, the day; when appearing at this time, the ancients styled it Phosphor or Lucifer (*the light-bearer*), and we call it the Morning Star. During the rest of the year, it rises after the Sun; it was then styled Hesperus or Vesper by the ancients, and is distinguished by us as the Evening Star.

Venus is very nearly of the same size as the Earth. Its diameter has generally been set down at 7,900 miles, somewhat less than the Earth's. In Herschel's latest Tables, however, it is given as 8,108, which makes it a little larger.

Venus's heat and light are twice as great as ours. So intense is its brightness that variations in its surface (if indeed its surface is not hid from us by a cloudy atmosphere) for the most part escape detection, every portion of the disk being flooded with light. Yet spots have occasionally been seen on its surface, and mountains have been observed having an estimated height of from 15 to 20 miles. Venus's phases, when viewed through the telescope, are similar to those of Mercury and the Moon; but it never appears exactly full, being invisible at the time when this phase would otherwise be presented.

967. The Earth (⊕).—The third planet from the Sun is the Earth, which we inhabit.

The form of the Earth is that of an oblate spheroid,—

What is stated with respect to Mercury's seasons? 966. What is the second planet from the Sun? How does it look to us, and why? What proofs have we of Venus's brightness? When is Venus called the Morning, and when the Evening Star? How does the size of Venus compare with that of the Earth? How do its heat and light compare with ours? What have been observed on Venus's surface? What phases does she present? 967. What is the third planet from the Sun? What is the form

that is, a sphere flattened at the poles like an orange. Its equatorial diameter is 7925.6 miles, and its polar diameter 26½ miles less. The circumference of a sphere is a little more than three times as great as its diameter; the distance round the earth, therefore, is about 25,000 miles.

The Earth is so large that its rotundity is not apparent to a person standing on its surface. We know it to be round, however, in several ways. 1. Navigators have sailed round it. By keeping the same general direction, east or west (as far as the land would allow), they have arrived at the place of starting. 2. The highest part of a vessel approaching in the distance is seen first, the lower part being obscured by the rotundity of the earth's surface. If the earth were a plain, we should see the hull as soon as the topmast.

968. *Motions.*—The Earth turns on its axis once in 24 hours. This is called its Diurnal Motion. Constantly bringing new points of the surface before the sun, and withdrawing others from its beams, this motion produces the succession of day and night.

The circumference of the earth being 25,000 miles, and a complete revolution being made in 24 hours, it follows that every point on the equator must revolve at the rate of a little over 1,000 miles an hour. As we go towards the poles, circles drawn round the earth parallel to the equator diminish in length, and points situated on them will consequently move with less velocity. At the poles there is no diurnal motion at all.

969. The Earth has also an Annual Motion,—about the Sun. Its orbit, like that of the other planets, is elliptical, but does not deviate much from a circle. Its perihelion is 3,000,000 miles nearer the Sun than its aphelion; consequently at the former point, other things being equal, it receives more heat than at any other part of its orbit.

The Earth reaches her perihelion on the 1st of January every year. Hence our winter is somewhat milder than that of the southern hemisphere; while the Sun at that period of a southern summer is perceptibly hotter than the summer sun at corresponding latitudes in the north. The heat in the inte-

of the Earth? What is its equatorial diameter? Its polar diameter? Its circumference? Why do we not see the roundness of the Earth? How do we know it to be round? 968. What is meant by the Earth's Diurnal Motion? What does it produce? What is the velocity of the diurnal motion at the equator? At the poles? At intermediate points? 969. What is meant by the Earth's Annual Motion? What is the shape of its orbit? When does the Earth receive the most solar heat, and why? How do the northern and southern winter and summer compare? Explain

rior of Australia at the time the Earth reaches her perihelion, is said to be more intense than any known even about the equator. Yet the difference of distance is so small compared with the whole, as not very materially to affect the Earth's temperature; nor has it anything to do with the change of seasons, as we shall presently see.

970. The Earth's orbit is nearly 600,000,000 miles in length; and to get round it in $365^{days}\ 5^{hrs.}\ 48^{m.}\ 48^{s.}$ (which is the period of its revolution and constitutes our year), it must travel over 68,000 miles an hour.

Though we are constantly moving with this great velocity, we are unconscious of it. This is because we have never known what it is to be at absolute rest; and again, the motion is perfectly easy and regular, there being no obstructions in the way to make us sensible of it.

971. *The Earth in Space.*—Space extends infinitely on all sides of the Earth, studded with stars at different distances. To us, however, the stars appear equally distant, and seem to lie on the inner surface of a vast hollow sphere, at the centre of which we are placed. For purposes of definition and description, it is often convenient thus to allude to the firmament; and the expressions "celestial arch", "concave surface of the heavens", are used for the purpose,—not to denote any real objects, but the apparent arch or concave surface that we may conceive to be thrown around us.

972. *Horizon, Zenith, Nadir.*—The Sensible Horizon is the line that bounds the view,—that is, where earth and sky appear to meet. To an observer on the ocean, or on a vast plain where there is nothing to obstruct the view, this line is always a circle. The plane passing through the sensible horizon, and infinitely extended through space, is called the Plane of the Sensible Horizon.

The Rational Horizon is a plane passing through the Earth's centre, parallel to the plane of the sensible horizon.

At the Earth these planes are separated by the distance between the centre and the surface, or 4,000 miles; but so small is this distance compared with that at which the stars are situated that the two planes are regarded as striking the celestial arch at the same point. All heavenly bodies above the rational horizon at any given point are visible, and all below it invisible.

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the cause. Is the Earth's temperature materially affected by this difference of distance? 970. With what velocity does the Earth travel round its orbit? Why are we not sensible of moving? 971. What is meant by the expressions, "celestial arch", "concave surface of the heavens"? 972. What is the Sensible Horizon? What is the Plane of the Sensible Horizon? What is the Rational Horizon? What

973. The Poles of the Horizon are two points in the heavens equally distant from the circle that bounds the view. One of these, the point directly overhead, is called the Ze′-nith; the opposite point, directly beneath us, is called the Na′-dir.

Every point on the Earth's surface has a horizon, zenith, and nadir of its own; and the horizon, zenith, and nadir of every point are constantly changing, owing to the revolution of the Earth on its axis. Hence, at night, new heavenly bodies are constantly coming into view in the east, while others are setting in the west.

974. *The Ecliptic.*—Seen from the Sun, the Earth would appear to describe a circle round that luminary, among the fixed stars on the concave surface of the heavens. This circle corresponds with the apparent path of the sun as seen from the Earth, and is called the Ecliptic.

The plane of the Earth's equator, extended till it meets the concave surface of the heavens, forms what is called the Celestial Equator, or the Equinoctial. The ecliptic and the equinoctial form an angle of 23° 28′, and this angle is called the Obliquity of the Ecliptic. The axis of the Earth, therefore, instead of being perpendicular to the plane of its orbit, is inclined to it at an angle of $(90° - 23° 28′)$ 66° 32′.

975. The ecliptic cuts the equinoctial at two points, called Equinoxes, because when the sun appears at these points the days and nights are equal all over the world.

The equinoxes are distinguished as Vernal and Autumnal. The Vernal Equinox is that point at which the sun crosses the equinoctial from south to north, which takes place in our spring. The Autumnal Equinox is the point

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is the distance between the two horizons at the Earth? When they strike the celestial arch? Which of the heavenly bodies are visible at any given point, and which invisible? 973. What are the Poles of the Horizon? What is the Zenith? The Nadir? What causes new heavenly bodies to keep coming into view at night and others to set? 974. What is the Ecliptic? What is the Celestial Equator, or Equinoctial? What is the Obliquity of the Ecliptic? 975. What are the Equinoxes? Why are they so called? How are they distinguished? What is the Vernal Equi-

at which the sun crosses the equinoctial from north to south,—and this he does in our autumn.

976. *The Zodiac.*—The Zodiac is a belt on the concave surface of the heavens, sixteen degrees in width, eight of which lie on each side of the ecliptic. It is divided into twelve Signs, of 30 degrees each. The zodiac is peculiarly interesting to us, because it is the region within which the apparent motions of the Sun, the Moon, and all the greater planets, are performed.

The zodiac is so called from a Greek word signifying *animal*, because its signs were for the most part named after animals, of which the stars in each seemed to the ancients to be so grouped as to form rude outlines. Such groups of stars, which seem to be situated near each other because lying in the same direction from us, are called Constellations. Owing to what is known as the Precession of the Equinoxes,—that is, the sun's completing its revolution on the ecliptic every year before it reaches the same point of the heavens relatively to the fixed stars,—the signs of the zodiac do not now correspond in position with the constellations from which they were named. With the equinoxes, on which their position depends, they have retrograded 30 degrees towards the west. The signs of the zodiac and the constellations of the zodiac must therefore be distinguished from each other.

977. The names of the signs of the zodiac are given below in Latin and English, with the characters by which they are respectively denoted. They are given in their order, commencing at the vernal equinox.

♈	*Aries*,	the ram.	
♉	*Taurus*,	the bull.	
♊	*Gemini*,	the twins.	
♋	*Cancer*,	the crab.	
♌	*Leo*,	the lion.	
♍	*Virgo*,	the virgin.	
♎	*Libra*,	the balance.	
♏	*Scorpio*,	the scorpion.	
♐	*Sagittarius*,	the archer.	
♑	*Capricornus*,	the goat.	
♒	*Aquarius*,	the water-bearer.	
♓	*Pisces*,	the fishes.	

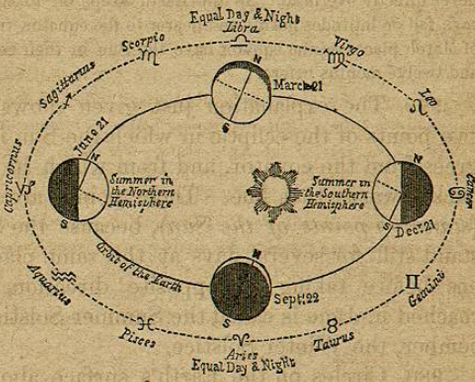
978. *The Change of Seasons.*—It has been stated that the Earth is nearer the Sun at one period of its revolution than at another. The change of seasons, however, is entirely independent of this fact, and is produced by the sun's rays falling on a given point of the Earth's surface with different degrees of obliquity at different parts of its orbit.

nox? What is the Autumnal Equinox? 976. What is the Zodiac? How is it divided? What makes it peculiarly interesting to us? From what is the zodiac so called? What are Constellations? How are the signs of the zodiac now situated relatively to the constellations from which they were named? To what is this owing? 977. Name the signs of the zodiac. 978. By what is the change of seasons produced? When is the Sun's heat most intense? Why does the angle at which the Sun's rays strike a given part of the Earth's surface keep varying? What does Fig. 334 represent? Describe the position of the Earth and the circumstances attending

When the Sun is vertical, or directly overhead, its heat is most intense; and the less its rays deviate from a vertical line in striking the surface, the more heat they impart to it.

The angle at which the Sun's rays strike a given part of the Earth's surface keeps constantly varying, in consequence of the Earth's revolving with its axis always pointing in the same direction, or, as it is generally expressed, everywhere parallel to itself. This will be understood from Fig. 334.

Fig. 334.



In Fig. 334 the Earth is represented as moving round the Sun, which is in one of the foci of her elliptical orbit. The dotted line is the zodiac, divided into its twelve signs. N S is the Earth's axis, which maintains the same direction in the four positions shown, and at every other part of the orbit.

At the vernal equinox (March 21), the equator is directly opposite the Sun; the solar rays fall at the same angle on the northern hemisphere as on the southern, and it is spring in the former, autumn in the latter. The Earth's axis is inclined neither to nor from the sun; consequently, half the surface, from pole to pole, is enlightened at a time, and day and night are of equal length all over the globe.

As the Earth moves eastward, the rays of the Sun no longer fall vertically on the equator, but on places north of it. This continues till June 21st, when the sun is vertical to places 23° 28′ north (this being the obliquity of the ecliptic), and his rays extend over the same distance beyond the north pole. It is now summer in the north and winter in the south, for in proportion as the solar rays fall less obliquely on the former, they must fall more obliquely on the latter. It will be observed, also, that a space extending 23° 28′ around the south pole is totally dark.

The Sun is never directly overhead to any place farther north of the equator than 23° 28′. As the Earth continues her course eastward, it becomes vertical to places more and more to the south, and by the 22d of September, or thereabouts, it is vertical to the equator just as it was six months before. This is the period of the autumnal equinox. The Earth again presents a full side from pole to pole to the Sun, and the days and nights are once more equal. We have now the southern spring and the northern autumn.

From this point, the solar rays become more and more oblique in the north and fall vertically on places farther and farther south, till the same limit of 23° 28′ is attained, which takes place about December 21, and marks the northern winter and the southern summer. Beyond this limit the Sun is never directly overhead. As the Earth keeps on to the east, his vertical rays fall on latitudes nearer and nearer to the equator, till finally on the 21st of March places on the equator have the Sun in their zenith as they had six and twelve months before.

979. The explanation just given shows that there are two points of the ecliptic in which the Sun is about 23½ degrees from the equator, and from which he seems to turn back towards that line. These points are called Solstices (*standing-points of the Sun*), because the Sun appears to stand still for several days at the same place in the heavens before taking an opposite direction. The solstice reached in June is called the Summer Solstice; that in December, the Winter Solstice.

980. Circles on the Earth's surface about 23½ degrees north and south of the equator form the limits beyond which the Sun's rays are never vertical. These circles are called Tropics (from a Greek word meaning *to turn*), because on reaching them the vertical rays turn back towards the equator. The northern tropic is called the Tropic of Cancer, because when the Sun reaches this line he is seen from the Earth in the sign Cancer, as will be apparent from Fig. 334. For a similar reason the southern tropic is called the Tropic of Capricorn.

981. It appears from Fig. 334 that from March 21 to September 22 the north pole is constantly illuminated and the south pole in darkness, notwithstanding the revolution of the Earth on its axis; while from September 22

it, at March 21. At June 21. At September 22. At December 21. 979. What are the Solstices? Why are they so called? How are they distinguished? 980. What are the Tropics? Whence is their name derived? What is the northern tropic

to March 21, darkness reigns at the north pole and the south pole enjoys continual light. At the summer solstice there is a space of 23½ degrees about the north pole on which the Sun does not set, and at the winter solstice a corresponding space about the south pole. The lines that bound these regions are called the Polar Circles. The one near the north pole is called the Arctic Circle; that near the south pole, the Antarctic Circle.

982. If, instead of being inclined, the Earth's axis were perpendicular to the plane of its orbit, the regions on the equator would have the Sun constantly in their zenith, day and night would always be equal over the whole globe, there would be no variety of seasons, and a given place would have about the same temperature from one year's end to another. Something of this kind must be the case on the planet Jupiter, whose axis is nearly perpendicular to the plane of its orbit. On the other hand, the more the axis of a planet is inclined, the greater are the extremes of temperature incident to its several seasons.

983. The Moon (☾).—The Earth is attended by one satellite called the Moon,—a beautiful orb which 'rules the night' with its gentle brilliancy, produces in part the tides, and sensibly affects the Earth's motions by its attraction.

984. *Size.*—The Moon's diameter is 2,165 miles, but its apparent size is almost equal to the Sun's in consequence of its nearness to our planet. Its density is not much more than one-half that of the Earth, and it contains about one-eightieth as much matter.

985. *Motions.*—The Moon is 240,000 miles from the Earth, and revolves about the latter so as to reach the same point relatively to the fixed stars in 27 days, 8 hours. To reach the same point relatively to the Sun requires 29 days, 13 hours, since the Earth has itself meanwhile advanced in its orbit.—When nearest the Earth, the Moon is said to be in her Per′-i-gee, and when farthest from it in her Ap′-o-gee.

The terms *perigee* and *apogee* (which mean *near the Earth* and *away from the Earth*) are also applied to the apparent position of the Sun. When the Earth is at its perihelion, the Sun is said to be in perigee; and when the Earth is at its aphelion, the Sun is in apogee.

called, and why? The southern? 981. What are the Polar Circles? What is the one near the north pole called? That near the south pole? 982. If the Earth's axis were perpendicular to the plane of its orbit, what would follow? What is said of Jupiter? 983. By what is the Earth attended? 984. How great is the Moon's diameter? Its density? Its mass? 985. How far is the Moon from the Earth? What is the period of her revolution? When is the Moon said to be in perigee? In ap-

The Moon also turns on its axis in exactly the same time that it takes to revolve round the Earth, and in the same direction. The consequence is that she always presents the same side to the Earth. Nearly one-half of our fair attendant we never see, and to the inhabitants of half her surface, if she has any, we are invisible.

986. *Phases.*—The Moon is non-luminous, and shines only by the reflected light of the Sun; hence the hemisphere presented to the Sun is bright, while the opposite one is dark. As the Sun, Moon, and Earth are constantly taking different positions relatively to each other, the portion of illuminated lunar surface presented to us is as constantly changing. Hence arise what are called the Phases of the Moon.

When *new*, the Moon lies between the Earth and the Sun, near a line connecting their centres. Her dark side is then towards us, and she is invisible. Soon, however, she gets so far east of the Sun as to appear in the west shortly after his setting. A bright crescent then becomes visible on the side nearest the Sun, the rest of her circular disk being just discernible, not by sun-light directly received, but by sun-light reflected from the Earth to the Moon, and by her reflected back to us. The crescent gradually grows larger, until, when the Moon is 90 degrees from the Sun, or in quadrature, half her disk is illumined. She is then said to be in her First Quarter.

Each succeeding night now finds the enlightened portion larger and larger, and the Moon is said to be *gibbous*. At last she reaches a point at which she is again almost in a line with the Sun and the Earth, but this time the Earth is in the middle. The Moon rises in the east as the Sun sets in the west; the whole of her enlightened hemisphere is therefore turned towards us, and she is said to be *full*.

After this the Moon again becomes gibbous, and we see less and less of her enlightened surface, till at length half of her disk is dark, when she is said to be in her Third Quarter. Advancing beyond her third quarter, she wanes still further to a crescent, and at length on arriving in conjunction with the Sun disappears entirely,—to go through the same phases again as she makes another revolution in her orbit.

987. To the inhabitants of the Moon, if any there be, the Earth presents the same phases that the Moon does to us, but in reversed order. When the Moon is new to us, the Earth is full to them,—a splendid orb, thirteen times

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ogee? When is the Sun said to be in perigee? In apogee? How long is the Moon in turning on her axis? What is the consequence? 986. What is said of the Moon's light? What causes her to present different phases to the Earth? Describe the phases successively presented. 987. What phases does the Earth present to the

as large as the full Moon. When she is in her first quarter, the Earth is in her third quarter, &c.

988. The Moon has either no atmosphere at all, or one exceedingly rare, and not extending more than a mile from its surface. Hence it must be destitute of water, for any liquid on its surface would long since have been dissipated by the heat of the lunar days, there being no atmospheric pressure to check evaporation. If there were any water on the surface of the Moon, clouds would certainly be observed at times dimming its face.

989. Viewed through a telescope, the surface of the Moon appears exceedingly rough, covered with isolated rocks, deep valleys, yawning chasms, craters of extinct volcanoes, in some cases more than 100 miles in width, and lofty mountains, several of which are from three to four miles high and cast their shadows a great distance over the rugged plains. Every thing is desolate in the extreme. Several of the earlier astronomers thought that they discerned volcanoes in a state of eruption; but later observers are of the contrary opinion, attributing the peculiar brightness of the supposed volcanic summits to phosphorescence, or superior reflective properties.

Names have been given to the various mountains and spots visible on the Moon, and a map has been prepared of the whole side presented to us, which has been pronounced "vastly more accurate than any map of the Earth we can yet produce."—The great telescope of the Earl of Rosse shows with distinctness every object on the lunar surface that is 100 feet in height. It has brought to light, however, no signs of life or habitation.

990. Mars (♂).—Mars, the fourth planet from the Sun, is 4,546 miles in diameter. Its day is of nearly the same length as ours, its year about twice as long. The inclination of its axis to the plane of its orbit does not differ much from the Earth's, and its seasons are therefore similar to ours. It is surrounded by an atmosphere of moderate density.

Mars is easily distinguished in the heavens by his red fiery light, which is supposed to owe its color to the soil from which it is reflected. The telescope distinctly shows continents of a dull red tinge, like that of sand-stone,

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Moon? 988. What is said of the Moon's atmosphere? Why is the Moon supposed to be destitute of water? 989. How does the Moon look, when viewed through a telescope? What is now thought respecting the supposed volcanic eruptions formerly observed? How high objects does the Earl of Rosse's telescope distinctly show? 990. Which is the fourth planet from the Sun? What is the length of its diameter? Its day? Its year? How do its seasons compare with ours? How may Mars be distinguished? What does the telescope show? What are seen about the