

presented a miniature representation of the Copernican system.

The announcement of these wonders at once attracted universal attention. The spiritual authorities were not slow to detect their tendency, as endangering the doctrine that the universe was made for man. In the creation of myriads of stars, hitherto invisible, there must surely have been some other motive than that of illuminating the nights for him.

It had been objected to the Copernican theory that, if the planets Mercury and Venus move round the sun in orbits interior to that of the earth, they ought to show phases like those of the moon; and that in the case of Venus, which is so brilliant and conspicuous, these phases should be very obvious. Copernicus himself had admitted the force of the objection, and had vainly tried to find an explanation. Galileo, on turning his telescope to the planet, discovered that the expected phases actually exist; now she was a crescent, then half-moon, then gibbous, then full. Previously to Copernicus, it was supposed that the planets shine by their own light, but the phases of Venus and Mars proved that their light is reflected. The Aristotelian notion, that celestial differ from terrestrial bodies in being incorruptible, received a rude shock from the discoveries of Galileo, that there are mountains and valleys in the moon like those of the earth, that the sun is not perfect, but has spots on his face, and that he turns on his axis instead of being in a state of majestic rest. The apparition of new stars had already thrown serious doubts on this theory of incorruptibility.

These and many other beautiful telescopic discoveries tended to the establishment of the truth of the Copernican theory and gave unbounded alarm to the

Church. By the low and ignorant ecclesiastics they were denounced as deceptions or frauds. Some affirmed that the telescope might be relied on well enough for terrestrial objects, but with the heavenly bodies it was altogether a different affair. Others declared that its invention was a mere application of Aristotle's remark that stars could be seen in the daytime from the bottom of a deep well. Galileo was accused of imposture, heresy, blasphemy, atheism. With a view of defending himself, he addressed a letter to the Abbe Castelli, suggesting that the Scriptures were never intended to be a scientific authority, but only a moral guide. This made matters worse. He was summoned before the Holy Inquisition, under an accusation of having taught that the earth moves round the sun, a doctrine "utterly contrary to the Scriptures." He was ordered to renounce that heresy, on pain of being imprisoned. He was directed to desist from teaching and advocating the Copernican theory, and pledge himself that he would neither publish nor defend it for the future. Knowing well that Truth has no need of martyrs, he assented to the required recantation, and gave the promise demanded.

For sixteen years the Church had rest. But in 1632 Galileo ventured on the publication of his work entitled "The System of the World," its object being the vindication of the Copernican doctrine. He was again summoned before the Inquisition at Rome, accused of having asserted that the earth moves round the sun. He was declared to have brought upon himself the penalties of heresy. On his knees, with his hand on the Bible, he was compelled to abjure and curse the doctrine of the movement of the earth. What a spectacle! This venerable man, the most illustrious of his age,

forced by the threat of death to deny facts which his judges as well as himself knew to be true! He was then committed to prison, treated with remorseless severity during the remaining ten years of his life, and was denied burial in consecrated ground. Must not that be false which requires for its support so much imposture, so much barbarity? The opinions thus defended by the Inquisition are now objects of derision to the whole civilized world.

One of the greatest of modern mathematicians, referring to this subject, says that the point here contested was one which is for mankind of the highest interest, because of the rank it assigns to the globe that we inhabit. If the earth be immovable in the midst of the universe, man has a right to regard himself as the principal object of the care of Nature. But if the earth be only one of the planets revolving round the sun, an insignificant body in the solar system, she will disappear entirely in the immensity of the heavens, in which this system, vast as it may appear to us, is nothing but an insensible point.

The triumphant establishment of the Copernican doctrine dates from the invention of the telescope. Soon there was not to be found in all Europe an astronomer who had not accepted the heliocentric theory with its essential postulate, the double motion of the earth—a movement of rotation on her axis, and a movement of revolution round the sun. If additional proof of the latter were needed, it was furnished by Bradley's great discovery of the aberration of the fixed stars, an aberration depending partly on the progressive motion of light, and partly on the revolution of the earth. Bradley's discovery ranked in importance with that of the precession of the equinoxes. Roemer's discovery of the pro-

gressive motion of light, though denounced by Fontenelle as a seductive error, and not admitted by Cassini, at length forced its way to universal acceptance.

Next it was necessary to obtain correct ideas of the dimensions of the solar system, or, putting the problem under a more limited form, to determine the distance of the earth from the sun.

In the time of Copernicus it was supposed that the sun's distance could not exceed five million miles, and indeed there were many who thought that estimate very extravagant. From a review of the observations of Tycho Brahe, Kepler, however, concluded that the error was actually in the opposite direction, and that the estimate must be raised to at least thirteen million. In 1670 Cassini showed that these numbers were altogether inconsistent with the facts, and gave as his conclusion eighty-five million.

The transit of Venus over the face of the sun, June 3, 1769, had been foreseen, and its great value in the solution of this fundamental problem in astronomy appreciated. With commendable alacrity various governments contributed their assistance in making observations, so that in Europe there were fifty stations, in Asia six, in America seventeen. It was for this purpose that the English Government dispatched Captain Cook on his celebrated first voyage. He went to Otaheite. His voyage was crowned with success. The sun rose without a cloud, and the sky continued equally clear throughout the day. The transit at Cook's station lasted from about half-past nine in the morning until about half-past three in the afternoon, and all the observations were made in a satisfactory manner.

But, on the discussion of the observations made at the different stations, it was found that there was not

the accordance that could have been desired—the result varying from eighty-eight to one hundred and nine million. The celebrated mathematician, Encke, therefore reviewed them in 1822-'24, and came to the conclusion that the sun's horizontal parallax, that is, the angle under which the semi-diameter of the earth is seen from the sun, is $8\frac{5}{10000}$ seconds; this gave as the distance 95,274,000 miles. Subsequently the observations were reconsidered by Hansen, who gave as their result 91,659,000 miles. Still later, Leverrier made it 91,759,000. Airy and Stone, by another method, made it 91,400,000; Stone alone, by a revision of the old observations, 91,730,000; and finally, Foucault and Fizeau, from physical experiments, determining the velocity of light, and therefore in their nature altogether differing from transit observations, 91,400,000. Until the results of the transit of next year (1874) are ascertained, it must therefore be admitted that the distance of the earth from the sun is somewhat less than ninety-two million miles.

This distance once determined, the dimensions of the solar system may be ascertained with ease and precision. It is enough to mention that the distance of Neptune from the sun, the most remote of the planets at present known, is about thirty times that of the earth.

By the aid of these numbers we may begin to gain a just appreciation of the doctrine of the human destiny of the universe—the doctrine that all things were made for man. Seen from the sun, the earth dwindles away to a mere speck, a mere dust-mote glistening in his beams. If the reader wishes a more precise valuation, let him hold a page of this book a couple of feet from his eye; then let him consider one of its dots or full-stops; that dot is several hundred times larger in surface than is the earth as seen from the sun!

Of what consequence, then, can such an almost imperceptible particle be? One might think that it could be removed or even annihilated, and yet never be missed. Of what consequence is one of those human monads, of whom more than a thousand millions swarm on the surface of this all but invisible speck, and of a million of whom scarcely one will leave a trace that he has ever existed? Of what consequence is man, his pleasures or his pains?

Among the arguments brought forward against the Copernican system at the time of its promulgation, was one by the great Danish astronomer, Tycho Brahe, originally urged by Aristarchus against the Pythagorean system, to the effect that, if, as was alleged, the earth moves round the sun, there ought to be a change of the direction in which the fixed stars appear. At one time we are nearer to a particular region of the heavens by a distance equal to the whole diameter of the earth's orbit than we were six months previously, and hence there ought to be a change in the relative position of the stars; they should seem to separate as we approach them, and to close together as we recede from them; or, to use the astronomical expression, these stars should have a yearly parallax.

The parallax of a star is the angle contained between two lines drawn from it—one to the sun, the other to the earth.

At that time, the earth's distance from the sun was greatly under-estimated. Had it been known, as it is now, that that distance exceeds ninety million miles, or that the diameter of the orbit is more than one hundred and eighty million, that argument would doubtless have had very great weight.

In reply to Tycho, it was said that, since the paral-

lax of a body diminishes as its distance increases, a star may be so far off that its parallax may be imperceptible. This answer proved to be correct. The detection of the parallax of the stars depended on the improvement of instruments for the measurement of angles.

The parallax of *α Centauri*, a fine double star of the Southern Hemisphere, at present considered to be the nearest of the fixed stars, was first determined by Henderson and Maclear at the Cape of Good Hope in 1832-'33. It is about nine-tenths of a second. Hence this star is almost two hundred and thirty thousand times as far from us as the sun. Seen from it, if the sun were even large enough to fill the whole orbit of the earth, or one hundred and eighty million miles in diameter, he would be a mere point. With its companion, it revolves round their common centre of gravity in eighty-one years, and hence it would seem that their conjoint mass is less than that of the sun.

The star 61 Cygni is of the sixth magnitude. Its parallax was first found by Bessel in 1838, and is about one-third of a second. The distance from us is, therefore, much more than five hundred thousand times that of the sun. With its companion, it revolves round their common centre of gravity in five hundred and twenty years. Their conjoint weight is about one-third that of the sun.

There is reason to believe that the great star Sirius, the brightest in the heavens, is about six times as far off as *α Centauri*. His probable diameter is twelve million miles, and the light he emits two hundred times more brilliant than that of the sun. Yet, even through the telescope, he has no measurable diameter; he looks merely like a very bright spark.

The stars, then, differ not merely in visible magni-

tude, but also in actual size. As the spectroscope shows, they differ greatly in chemical and physical constitution. That instrument is also revealing to us the duration of the life of a star, through changes in the refrangibility of the emitted light. Though, as we have seen, the nearest to us is at an enormous and all but immeasurable distance, this is but the first step—there are others the rays of which have taken thousands, perhaps millions, of years to reach us! The limits of our own system are far beyond the range of our greatest telescopes; what, then, shall we say of other systems beyond? Worlds are scattered like dust in the abysses in space.

Have these gigantic bodies—myriads of which are placed at so vast a distance that our unassisted eyes cannot perceive them—have these no other purpose than that assigned by theologians, to give light to us? Does not their enormous size demonstrate that, as they are centres of force, so they must be centres of motion—suns for other systems of worlds?

While yet these facts were very imperfectly known—indeed, were rather speculations than facts—Giordano Bruno, an Italian, born seven years after the death of Copernicus, published a work on the "Infinity of the Universe and of Worlds;" he was also the author of "Evening Conversations on Ash-Wednesday," an apology for the Copernican system, and of "The One Sole Cause of Things." To these may be added an allegory published in 1584, "The Expulsion of the Triumphant Beast." He had also collected, for the use of future astronomers, all the observations he could find respecting the new star that suddenly appeared in Cassiopeia, A. D. 1572, and increased in brilliancy, until it surpassed all the other stars. It could be plainly seen in the daytime. On a sudden, November 11th, it was as bright

as Venus at her brightest. In the following March it was of the first magnitude. It exhibited various hues of color in a few months, and disappeared in March, 1574.

The star that suddenly appeared in Serpentarius, in Kepler's time (1604), was at first brighter than Venus. It lasted more than a year, and, passing through various tints of purple, yellow, red, became extinguished.

Originally, Bruno was intended for the Church. He had become a Dominican, but was led into doubt by his meditations on the subjects of transubstantiation and the immaculate conception. Not caring to conceal his opinions, he soon fell under the censure of the spiritual authorities, and found it necessary to seek refuge successively in Switzerland, France, England, Germany. The cold-scented sleuth-hounds of the Inquisition followed his track remorselessly, and eventually hunted him back to Italy. He was arrested in Venice, and confined in the Piombi for six years, without books, or paper, or friends.

In England he had given lectures on the plurality of worlds, and in that country had written, in Italian, his most important works. It added not a little to the exasperation against him, that he was perpetually declaiming against the insincerity, the impostures, of his persecutors—that wherever he went he found skepticism varnished over and concealed by hypocrisy; and that it was not against the belief of men, but against their pretended belief, that he was fighting; that he was struggling with an orthodoxy that had neither morality nor faith.

In his "Evening Conversations" he had insisted that the Scriptures were never intended to teach science, but morals only; and that they cannot be received as of

any authority on astronomical and physical subjects. Especially must we reject the view they reveal to us of the constitution of the world, that the earth is a flat surface, supported on pillars; that the sky is a firmament—the floor of heaven. On the contrary, we must believe that the universe is infinite, and that it is filled with self-luminous and opaque worlds, many of them inhabited; that there is nothing above and around us but space and stars. His meditations on these subjects had brought him to the conclusion that the views of Averroes are not far from the truth—that there is an Intellect which animates the universe, and of this Intellect the visible world is only an emanation or manifestation, originated and sustained by force derived from it, and were that force withdrawn, all things would disappear. This ever-present, all-pervading Intellect is God, who lives in all things, even such as seem not to live; that every thing is ready to become organized, to burst into life. God is, therefore, "the One Sole Cause of Things," "the All in All."

Bruno may hence be considered among philosophical writers as intermediate between Averroes and Spinoza. The latter held that God and the Universe are the same, that all events happen by an immutable law of Nature, by an unconquerable necessity; that God is the Universe, producing a series of necessary movements or acts, in consequence of intrinsic, unchangeable, and irresistible energy.

On the demand of the spiritual authorities, Bruno was removed from Venice to Rome, and confined in the prison of the Inquisition, accused not only of being a heretic, but also a heresiarch, who had written things unseemly concerning religion; the special charge against him being that he had taught the plurality of worlds, a

doctrine repugnant to the whole tenor of Scripture and inimical to revealed religion, especially as regards the plan of salvation. After an imprisonment of two years he was brought before his judges, declared guilty of the acts alleged, excommunicated, and, on his nobly refusing to recant, was delivered over to the secular authorities to be punished "as mercifully as possible, and without the shedding of his blood," the horrible formula for burning a prisoner at the stake. Knowing well that though his tormentors might destroy his body, his thoughts would still live among men, he said to his judges, "Perhaps it is with greater fear that you pass the sentence upon me than I receive it." The sentence was carried into effect, and he was burnt at Rome, February 16th, A. D. 1600.

No one can recall without sentiments of pity the sufferings of those countless martyrs, who first by one party, and then by another, have been brought for their religious opinions to the stake. But each of these had in his supreme moment a powerful and unflinching support. The passage from this life to the next, though through a hard trial, was the passage from a transient trouble to eternal happiness, an escape from the cruelty of earth to the charity of heaven. On his way through the dark valley the martyr believed that there was an invisible hand that would lead him, a friend that would guide him all the more gently and firmly because of the terrors of the flames. For Bruno there was no such support. The philosophical opinions, for the sake of which he surrendered his life, could give him no consolation. He must fight the last fight alone. Is there not something very grand in the attitude of this solitary man, something which human nature cannot help admiring, as he stands in the gloomy hall before his inex-

orable judges? No accuser, no witness, no advocate is present, but the familiars of the Holy Office, clad in black, are stealthily moving about. The tormentors and the rack are in the vaults below. He is simply told that he has brought upon himself strong suspicions of heresy, since he has said that there are other worlds than ours. He is asked if he will recant and abjure his error. He cannot and will not deny what he knows to be true, and perhaps—for he had often done so before—he tells his judges that they, too, in their hearts are of the same belief. What a contrast between this scene of manly honor, of unshaken firmness, of inflexible adherence to the truth, and that other scene which took place more than fifteen centuries previously by the fireside in the hall of Caiaphas the high-priest, when the cock crew, and "the Lord turned and looked upon Peter" (Luke xxii. 61)! And yet it is upon Peter that the Church has grounded her right to act as she did to Bruno.

But perhaps the day approaches when posterity will offer an expiation for this great ecclesiastical crime, and a statue of Bruno be unveiled under the dome of St. Peter's at Rome.

CHAPTER VII.

CONTROVERSY RESPECTING THE AGE OF THE EARTH.

Scriptural view that the Earth is only six thousand years old, and that it was made in a week.—Patristic chronology founded on the ages of the patriarchs.—Difficulties arising from different estimates in different versions of the Bible.

Legend of the Deluge.—The re-peopling.—The Tower of Babel; the confusion of tongues.—The primitive language.

Discovery by Cassini of the oblateness of the planet Jupiter.—Discovery by Newton of the oblateness of the Earth.—Deduction that she has been modeled by mechanical causes.—Confirmation of this by geological discoveries respecting aqueous rocks; corroboration by organic remains.—The necessity of admitting enormously long periods of time.—Displacement of the doctrine of Creation by that of Evolution—Discoveries respecting the Antiquity of Man.

The time-scale and space-scale of the world are infinite.—Moderation with which the discussion of the Age of the World has been conducted.

THE true position of the earth in the universe was established only after a long and severe conflict. The Church used whatever power she had, even to the infliction of death, for sustaining her ideas. But it was in vain. The evidence in behalf of the Copernican theory became irresistible. It was at length universally admitted that the sun is the central, the ruling body of our system; the earth only one, and by no means the largest, of a family of encircling planets.

Taught by the issue of that dispute, when the ques-

tion of the age of the world presented itself for consideration, the Church did not exhibit the active resistance she had displayed on the former occasion. For, though her traditions were again put in jeopardy, they were not, in her judgment, so vitally assailed. To dethrone the Earth from her dominating position was, so the spiritual authorities declared, to undermine the very foundation of revealed truth; but discussions respecting the date of creation might within certain limits be permitted. Those limits were, however, very quickly overpassed, and thus the controversy became as dangerous as the former one had been.

It was not possible to adopt the advice given by Plato in his "Timæus," when treating of this subject—the origin of the universe: "It is proper that both I who speak and you who judge should remember that we are but men, and therefore, receiving the probable mythological tradition, it is meet that we inquire no further into it." Since the time of St. Augustine the Scriptures had been made the great and final authority in all matters of science, and theologians had deduced from them schemes of chronology and cosmogony which had proved to be stumbling-blocks to the advance of real knowledge.

It is not necessary for us to do more than to allude to some of the leading features of these schemes; their peculiarities will be easily discerned with sufficient clearness. Thus, from the six days of creation and the Sabbath-day of rest, since we are told that a day is with the Lord as a thousand years, it was inferred that the duration of the world will be through six thousand years of suffering, and an additional thousand, a millennium of rest. It was generally admitted that the earth was about four thousand years old at the birth of Christ,

but, so careless had Europe been in the study of its annals, that not until A. D. 527 had it a proper chronology of its own. A Roman abbot, Dionysius Exiguus, or Dennis the Less, then fixed the vulgar era, and gave Europe its present Christian chronology.

The method followed in obtaining the earliest chronological dates was by computations, mainly founded on the lives of the patriarchs. Much difficulty was encountered in reconciling numerical discrepancies. Even if, as was taken for granted in those uncritical ages, Moses was the author of the books imputed to him, due weight was not given to the fact that he related events, many of which took place more than two thousand years before he was born. It scarcely seemed necessary to regard the Pentateuch as of plenary inspiration, since no means had been provided to perpetuate its correctness. The different copies which had escaped the chances of time varied very much; thus the Samaritan made thirteen hundred and seven years from the Creation to the Deluge, the Hebrew sixteen hundred and fifty-six, the Septuagint twenty-two hundred and sixty-three. The Septuagint counted fifteen hundred years more from the Creation to Abraham than the Hebrew. In general, however, there was an inclination to the supposition that the Deluge took place about two thousand years after the Creation, and, after another interval of two thousand years, Christ was born. Persons who had given much attention to the subject affirmed that there were not less than one hundred and thirty-two different opinions as to the year in which the Messiah appeared, and hence they declared that it was inexpedient to press for acceptance the Scriptural numbers too closely, since it was plain, from the great differences in different copies, that there had been no providential

intervention to perpetuate a correct reading, nor was there any mark by which men could be guided to the only authentic version. Even those held in the highest esteem contained undeniable errors. Thus the Septuagint made Methuselah live until after the Deluge.

It was thought that, in the antediluvian world, the year consisted of three hundred and sixty days. Some even affirmed that this was the origin of the division of the circle into three hundred and sixty degrees. At the time of the Deluge, so many theologians declared, the motion of the sun was altered, and the year became five days and six hours longer. There was a prevalent opinion that that stupendous event occurred on November 2d, in the year of the world 1656. Dr. Whiston, however, disposed to greater precision, inclined to postpone it to November 28th. Some thought that the rainbow was not seen until after the flood; others, apparently with better reason, inferred that it was then first established as a sign. On coming forth from the ark, men received permission to use flesh as food, the antediluvians having been herbivorous! It would seem that the Deluge had not occasioned any great geographical changes, for Noah, relying on his antediluvian knowledge, proceeded to divide the earth among his three sons, giving to Japhet Europe, to Shem Asia, to Ham Africa. No provision was made for America, as he did not know of its existence. These patriarchs, undeterred by the terrible solitudes to which they were going, by the undrained swamps and untracked forests, journeyed to their allotted possessions, and commenced the settlement of the continents.

In seventy years the Asiatic family had increased to several hundred. They had found their way to the plains of Mesopotamia, and there, for some motive that