

Dialogue Concerning the Two Chief World Systems by Galileo Galilei (1632)



Cover Page

Translated by Stillman Drake
Annotated and Condensed by S. E. Sciortino

The open-minded and lettered Sagredo in Galileo's dialogue was a close friend of the scientist. Salviati represents the views of Galileo himself. Simplicio, the philosopher, is a fictitious straw man.

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TO THE DISCERNING READER

Several years ago there was published in Rome a salutary edict which, in order to obviate the dangerous tendencies of our present age, imposed a seasonable silence upon the Pythagorean opinion that the earth moves. There were those who impudently asserted that this decree had its origin not in judicious inquiry, but in passion. None too well informed complaints were to be heard that advisers who were totally unskilled at astronomical observations ought not to clip the wings of reflective intellects by means of rash prohibitions.

Upon hearing such carping insolence, my zeal could not be contained. Being thoroughly informed about that prudent determination, I decided to appear openly in the theater of the world as a witness of the sober truth. I was at that time in Rome; I was not only received by

the most eminent prelates of that Court, but had their applause; indeed this decree was not published without some previous notice of it having been given to me. Therefore I propose in the present work to show to foreign nations that as much is understood of this matter in Italy, and particularly in Rome, as transalpine diligence can ever have imagined Collecting all the reflections that properly concern the Copernican system, I shall make it known that everything was brought before the attention of the Roman censorship, and that there proceed from this clime not only dogmas for the welfare of the soul, but ingenious discoveries for the delight of the mind as well.

To this end I have taken the Copernican side in the discourse, proceeding as with a pure mathematical hypothesis and striving by every artifice to represent it as superior to supposing the earth motionless—not, indeed absolutely, but as against the arguments of some professed Peripatetics. These men indeed deserve not even that name, for they do not walk about; they are content to adore the shadows, philosophizing not with due circumspection but merely from having memorized a few ill-understood principles.

Three principal headings are treated First, I shall try to show that all experiments practicable upon the earth are insufficient measures for proving its mobility, since they are indifferently adaptable to an earth in motion or at rest. I hope in so doing to reveal many observations unknown to the ancients. Secondly, the celestial phenomena will be examined strengthening the Copernican hypothesis until it might seem that this must triumph absolutely. Here new reflections are adjoined which might be used in order to simplify astronomy, though not because of any necessity imported by nature. In the third place, I shall propose an ingenious speculation. It happens that long ago I said that the unsolved problem of the ocean tides might receive some light from assuming the motion of the earth. This assertion of mine, passing by word of mouth, found loving fathers who adopted it as a child of their own ingenuity. Now, so that no stranger may ever a who, arming himself with our weapons, shall charge us with want of attention to such an important matter, I have thought it good to reveal those probabilities which might render this plausible, given that the earth moves.

I hope that from these considerations the world will come to know that if other nations have navigated more, we have not theorized less. It is not from failing to take count of what others have thought that we have yielded to asserting that the earth is motionless, and holding the contrary to be a mere mathematical caprice, but (if for nothing else) for those reasons that are supplied by piety, religion, the knowledge of Divine Omnipotence, and a consciousness of the limitations of the human mind I have thought it most appropriate to explain these concepts in the form of dialogues, which, no! being restricted to the rigorous observance of mathematical laws, make room also for digressions which are sometimes no less interesting than the principal argument.

Many years ago I was often to be found in the marvelous city of Venice, in discussions with Signore Giovanni Francesco Sagredo, a man of noble extraction and trenchant wit. From Florence came Signore Filippo Salviati, the least of whose glories were the eminence of his blood and the magnificence of his fortune. His was a sublime intellect which fed no more hungrily upon any pleasure than it did upon fine meditations. I often talked with these two of such matters in the presence of a certain Peripatetic philosopher whose greatest obstacle in apprehending the truth seemed to be the reputation he had acquired by his interpretations of Aristotle.

Now, since bitter death has deprived Venice and Florence of those two great luminaries in the very meridian of their years, I have resolved to make their fame live on in these pages, so far

as my poor abilities will permit, by introducing them as interlocutors in the present argument. (Nor shall the good Peripatetic lack a place; because of his excessive affection toward the Commentaries of Simplicius, I have thought fit to leave him under the name of the author he so much revered, without mentioning his own) May it please those two great souls, ever venerable to my heart, to accept this public monument of my undying love. And may the memory of their eloquence assist me in delivering to posterity the promised reflections.

It happened that several discussions had taken place casually at various times among these gentlemen, and had rather whetted than satisfied their thirst for learning. Hence very wisely they resolved to meet together on certain days during which, setting aside all other business, they might apply themselves more methodically to the contemplation of the wonders of God in the heavens and upon the earth. They met in the palace of the illustrious Sagredo; and, after the customary but brief exchange of compliments, Saiviati commenced as follows.

THE FIRST DAY

INTERLOCUTORS

SALVIATI, SAGRFD0, AND SIIMPLICIO

SALVIATI. Yesterday we resolved to meet today and discuss as clearly and in as much detail as possible the character and the efficacy of those laws of nature which up to the present have been put forth by the partisans of the Aristotelian and Ptolemaic position on the one hand, and by the followers of the Copemican system on the other. Since Copernicus places the earth among the movable heavenly bodies, making it a globe like a planet, we may well begin our discussion by examining the Peripatetic steps in arguing the impossibility of that hypothesis; what they are, and how great is their force and effect. For this it is necessary to introduce into nature two substances which differ essentially. These are the celestial and the elemental, the former being invariant and eternal the latter, temporary and destructible. This argument Aristotle treats in his book *De Caelo*, introducing it with some discourses dependent upon certain general assumptions, and afterwards confirming it by experiments and specific demonstrations. Following the same method, I shall first propound, and then freely speak my opinion, submitting myself to your criticisms -- particularly those of Simplicio, that stout champion and defender of Aristotelian doctrines.

The first step in the Peripatetic arguments is Aristotle's proof of the completeness and perfection of the world. For, he tells us, it is not a mere line, nor a bare surface, but a body having length, breadth, and depth. Since there are only these three dimensions, the world, having these, has them all, and, having the Whole, is perfect. To be sure, I much wish that Aristotle had proved to me by rigorous deductions that simple length constitutes the dimension which we call a line, which by the addition of breadth becomes a surface; that by further adding altitude or depth to this there results a body, and that after these three dimensions there is no passing farther, so that by these three alone, completeness, or, so to speak, wholeness is concluded. Especially since he might have done so very plainly and speedily.

SIMP. What about the elegant demonstrations in the second, third, and fourth texts, after the definition of "continuous"? Is it not there first proved that there are no more than three

dimensions, since Three is everything, and everywhere? And is this not confirmed by the doctrine and authority of the Pythagoreans, who say that all things are determined by three -- beginning, middle, and end -- which is the number of the Whole? Also, why leave out another of his reasons; namely, that this number is used, as if by a law of nature, in sacrifices to the gods? Furthermore, is it not dictated by nature that we attribute the title of "all" to those things that are three, and not less? For two are called "both," and one does not say "all" unless there are three.

You have all this doctrine in the second text. Afterwards, in the third we read, for greater knowledge that All, and Whole, and Perfect are formally one and the same; and that therefore among figures only the solid is complete. For it alone is determined by three, which is All; and, being divisible in three ways, it is divisible in every possible way. Of the other figures, one is divisible in one way, and the other in two, because they have their divisibility and their continuity according to the number of dimensions allotted to them. Thus one figure is continuous in one way, the other in two; but the third, namely the solid, is so in every way.

Moreover, in the fourth text, after some other doctrines, does he not clinch the matter with another proof? To wit: a transition is made only according to some defect; thus there is a transition in passing from the line to the surface, because the line is lacking in breadth. But it is impossible for the perfect to lack anything, being complete in every way; therefore there is no transition beyond the solid or body to any other figure.

Do you not think that in all these places he has sufficiently proved that there is no passing beyond the three dimensions, length, breadth, and thickness; and that therefore the body, or solid, which has them all, is perfect?

SALV. To tell you the truth, I do not feel impelled by all these reasons to grant any more than this: that whatever has a beginning, middle, and end may and ought to be called perfect. I feel no compulsion to grant that the number three is a perfect number, nor that it has a faculty of conferring perfection upon its possessors. I do not even understand, let alone believe, that with respect to legs, for example, the number three is more perfect than four or two; neither do I conceive the number four to be any imperfection in the elements, nor that they would be more perfect if they were three. Therefore it would have been better for him to leave these subtleties to the rhetoricians, and to prove his point by rigorous demonstrations such as are suitable to make in the demonstrative sciences.

SIMP. It seems that you ridicule these reasons, and yet all of them are doctrines to the Pythagoreans, who attribute so much to numbers. You, who are a mathematician, and who believe many Pythagorean philosophical opinions, now seem to scorn their mysteries.

SALV. That the Pythagoreans held the science of the human understanding and believed it to partake of divinity simply because it understood the nature of numbers, I know very well; nor am I far from being of the same opinion. But that these mysteries which caused Pythagoras and his sect to have such veneration for the science of numbers are the follies that abound in the sayings and Writings of the vulgar, I do not believe at all. Rather I know that, in order to prevent the things they admired from being exposed to the slander and scorn of the common people, the Pythagoreans condemned as sacrilegious the publication of the most hidden properties of numbers or of the incommensurable and irrational quantities which they investigated. They taught that anyone who had revealed them was tormented in the other world. Therefore I believe that some one of them, just to satisfy the common sort and free himself from their inquisitiveness, gave it out that the mysteries of numbers were those trifles

which later spread among the vulgar. Such astuteness and prudence remind one of the wise young man who, in order to stop the importunity of his mother or his inquisitive wife -- I forget which -- who pressed him to impart the secrets of the Senate, made up some story which afterwards caused her and many other women to be the laughing-stock of that same Senate.

SIMP. I do not want to join the number of those who are too curious about the Pythagorean mysteries. But as to the point in hand, I reply that the reasons produced by Aristotle to prove that there are not and cannot be more than three dimensions seem to me conclusive; and I believe that if a more cogent demonstration had existed, Aristotle would not have omitted it.

SAGR. You might at least add, "if he had known it or if it had occurred to him." Salviati, you would be doing me a great favor by giving me some effective arguments. if there are any clear enough to be comprehended by me.

SALV. Not only by you, but by Simplicio too; and not merely comprehended, but already known -- though perhaps without your realizing it. And to make them easier to understand, let us take this paper and pen which I see already prepared for such occasions, and draw a few figures.

First we shall mark these two points, A and B, and draw from one to the other the curved lines ACB and ADE, and the straight line P3. (Fig. 1) I ask which of them is to your mind the one that determines the distance between the ends A and B, and why?

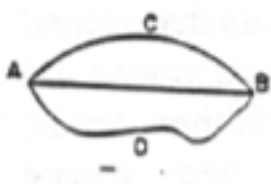


Figure 1

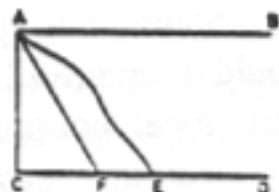


Figure 2

SAGR. I should say the straight line, and not the curves, because the straight one is shorter and because it is unique, distinct, and determinate; the infinite others are indefinite, unequal, and longer. It seems to me that the choice ought to depend upon that which is unique and definite.

SALV. We have the straight line, then, as determining the distance between the two points.

We now add another straight line parallel to AB -- let it be CD -- so that between them there lies a surface of which I want you to show the breadth. (Fig. 2) Therefore starting from point A, tell me how and which way you will go, stopping on the line CD, so as to show me the breadth included between those lines. Would you determine it according to the measure of the curve AF, or the straight line AF, or. . . ?

SIMP. According to the straight line AF, and not according to the curve, such being already excluded for such a use.

SAGR. But I should take neither of them, seeing that the straight line AF runs obliquely. I should draw a line perpendicular to CD, for this would seem to me to be the shortest, as well as being unique among the infinite number of longer and unequal ones which may be drawn from the point A to every other point of the opposite line CD.

SALV. Your choice and the reason you adduce for it seem to me most excellent. So now we have it that the first dimension is determined by a straight line; the second (namely, breadth) by another straight line, and not only straight, but at right angles to that which determines the length. Thus we have defined the two dimensions of a surface; that is, length and breadth.

But suppose you had to determine a height -- for example, how high this platform is from the

pavement down below there. Seeing that from any point in the platform we may draw infinite lines, curved or straight, and all of different lengths, to the infinite points of the pavement below, which of all these lines would you make use of?

SAGR. I would fasten a string to the platform and, by hanging a plummet from it, would let it freely stretch till it reached very near to the pavement; the length of such a string being the straightest and shortest of all the lines that could possibly be drawn from the same point to the pavement, I should say that it was the true height in this case.

SALV. Very good. And if, from the point on the pavement indicated by this hanging string (taking the pavement to be level and not inclined), you should produce two other straight lines, one for the length and the other for the breadth of the surface of the pavement, what angles would they make with the thread?

SAGR. They would surely meet at right angles, since the string falls perpendicularly and the pavement is quite flat and level.

SALV. Therefore if you assign any point for the point of origin of your measurements, and from that produce a straight line as the determinant of the first measurement (that is, of the length) it will necessarily follow that the one which is to define the breadth leaves the first at a right angle. That which is to denote the altitude, which is the third dimension, going out from the same point, also forms right angles and not oblique angles with the other two. And thus by three perpendiculars you will have determined the three dimensions AB length, AC breadth, and AD height, by three unique, definite, and shortest lines. (Fig. 3) And since clearly no more lines can meet in the said point to make right angles with them, and the dimensions must be determined by the only straight lines which make right angles with each other, then the dimensions are no more than three; and whatever has the three has all of them, and that which has all of them is divisible in every way, and that which is so, is perfect, etc.

SIMP. Who says that I cannot draw other lines? Why may I not bring another line from beneath to the point A, which will be perpendicular to the rest?

SALV. Surely you cannot make more than three straight lines meet in the same point and form right angles with each other!

SAGR. Yes, because it seems to me that what Simplicio means would be the same DA prolonged downward. In that way there might also be drawn two others; but they would be the same as the first three, differing only in that whereas now they merely touch, they would then intersect. But this would not produce any new dimensions.

SIMP. I shall not say that this argument of yours cannot be conclusive. But I still say, with Aristotle, that in physical matters one need not always require a mathematical demonstration.

SAGR. Granted, where none is to be had; but when there is one at hand, why do you not wish to use it? But it would be good to spend no more words on this point, for I think that Salviati will have conceded both to Aristotle and to you, without further demonstration, that the world is a body, and perfect; yea, most perfect, being the chief work of God.

SALV. Exactly so. Therefore leaving the general contemplation of the whole, let us get to the consideration of the parts. Aristotle in his first division separates the whole into two differing and, in a way, contrary parts: namely, the celestial and the elemental, the former being ingenerable, incorruptible, inalterable, impenetrable, etc.; the latter being exposed to continual

alteration, mutation, etc. He takes this difference from the diversity of local motions as his original principle. With this step he proceeds.

Leaving, so to speak, the sensible world and retiring into the ideal world, he begins architectonically to consider that, nature being the principle of motion, it is appropriate that natural bodies should be endowed with local motion. He then declares local motions to be of three kinds: namely, circular, straight, and mixed straight-and-circular. The first two he calls simple, because of all lines only the circular and the straight are simple. Hereupon, restricting himself somewhat, he newly defines among the simple motions one, the circular, to be that which is made around the center; and the other, the straight, to be upward and downward -- upward, that which goes from the center; and downward, whatever goes toward the center. And from this he infers it to be necessary and proper that all simple motions are confined to these three kinds; namely, toward the center, away from the center, and around the center. This answers, he says, with a certain beautiful harmony to what has been said previously about the body; it is perfect in three things, and its motion is likewise.

These motions being established, he goes on to say that some natural bodies being simple, and others composites of those (and he calls those bodies simple which have a natural principle of motion, such as fire and earth), it is proper that simple motions should be those of simple bodies, and that mixed motions should belong to compound bodies; in such a way, moreover, that compounds take the motion of that part which predominates in their composition.

SAGR. Wait awhile, Salviati, for in this argument I find so many doubts assailing me on all sides that I shall either have to tell them to you if I want to pay attention to what you are going to say, or withhold my attention in order to remember my doubts.

SALV. I shall willingly pause, for I run the same risk too, and am on the verge of getting shipwrecked. At present I sail between rocks and boisterous waves that are making me lose my bearings, as they say. Therefore, before I multiply your difficulties, propound them.

[Discussion of earth's place in the solar system:]

SALV. I see we are once more going to engulf ourselves in a boundless sea from which there is no getting out, ever. This is navigating without compass, stars, oars, or rudder, in which we must needs either pass from bank to bank or run aground, or sail forever lost. If, as you suggested, we are to get on with our main subject, it is necessary for the present to put aside the general question whether straight motion is necessary in nature and is proper to some bodies, and proceed to demonstrations, observations, and particular experiments. First we must propound all those that have been put forward to prove the earth's stability by Aristotle, Ptolemy, and others, trying next to resolve them. Finally we must produce those by which a person may become persuaded that the earth, no less than the moon or any other planet, is to be numbered among the natural bodies that move circularly.

SAGR. I submit to the latter more willingly, as I am better satisfied with your architectonic and general discourse than with that of Aristotle. For yours satisfies me without the least misgiving, while the other blocks me in some way at every turn. Nor do I know why Simplicio should not be quickly satisfied with the argument you put forward to prove that motion in a straight line can have no place in nature, so long as we suppose the parts of the universe to be disposed in the best arrangement and perfectly ordered.

SALV. Stop there, Sagredo. for now a way occurs to me in which Simplicio may be given satisfaction, provided only that he does not wish to stay so closely tied to every phrase of

Aristotle's as to hold it sacrilege to depart from a single one of them.

There is no doubt that to maintain the optimum placement and perfect order of the parts of the universe as to local situation, nothing will do but circular motion or rest. As to motion by a straight line, I do not see how it can be of use for anything except to restore to their natural location such integral bodies as have been accidentally removed and separated from their whole, as we have just said.

Let us now consider the whole terrestrial globe, and let us see what can happen to make it and the other world bodies keep themselves in the natural and best disposition. One must either say that it is at rest and remains perpetually immovable in its place, or else that it stays always in its place but revolves itself, or finally that it goes about a center, moving along the circumference of a circle. Of these events, Aristotle and Ptolemy and all their followers say that it is the first which has always been observed and which will be forever maintained; that is, perpetual rest in the same place. Now why, then, should they not have said from the start that its natural property is to remain motionless, rather than making its natural motion downward, a motion with which it never did and never will move? And as to motion by a straight line, let it be granted to us that nature makes use of this to restore particles of earth, water, air, fire, and every other integral mundane body to their whole, when any of them find themselves separated and transported into some improper place unless this restoration can also be made by finding some more appropriate circular motion. It seems to me that this original position fits all the consequences much better, even by Aristotle's own method, than to attribute straight motion as an intrinsic and natural principle of the elements. This is obvious; for let me ask the Peripatetic if, being of the opinion that celestial bodies are incorruptible and eternal, he believes that the terrestrial globe is not so, but corruptible and mortal, so that there will come a time when, the sun and moon and other stars continuing their existence and their operations, the earth will not be found in the universe but will be annihilated along with the rest of the elements, and I am certain that he would answer, No. Therefore generation and corruption belong to the parts and not to the whole; indeed, to very small and superficial parts which are insensible in comparison to the whole mass. Now since Aristotle argues generation and corruption from the contrariety of straight motions, let us grant such motions to the parts, which alone change and decay. But to the whole globe and sphere of the elements will be ascribed either circular motion or perpetual continuance in its proper place -- the only tendencies fitted for the perpetuation and maintenance of perfect order.

What is thus said of earth may be said as reasonably of fire and of the greater part of the air, to which elements the Peripatetics are forced to assign as an intrinsic and natural motion one with which they were never moved and never will be, and to abolish from nature that motion with which they move, have moved, and are to be moved perpetually. I say this because they assign an upward motion to air and fire, which is a motion that never belongs to the said elements, but only to some of their particles -- and even then only to restore them to perfect arrangement when they are out of their natural places. On the other hand, they call circular motion (with which they are incessantly moved) preternatural to them, forgetting what Aristotle has said many times, that nothing violent can last very long.

SIMP. To all these things we have the most suitable answers, which I omit for the present in order that we may come to the particular reasons and sensible experiments which ought to be finally preferred, as Aristotle well says, above anything that can be supplied by human argument.

SAGR. Then what has been said up to now will serve to place under consideration which of

two general arguments has the more probability. First there is that of Aristotle, who would persuade us that sublunar bodies are by nature generable and corruptible, etc., and are therefore very different in essence from celestial bodies, these being invariant, ingenerable, incorruptible, etc. This argument is deduced from differences of simple motions. Second is that of Salviati, who assumes the integral parts of the world to be disposed in the best order, and as a necessary consequence excludes straight motions for simple natural bodies as being of no use in nature; he takes the earth to be another of the celestial bodies, endowed with all the prerogatives that belong to them. The latter reasoning suits me better up to this point than the other. Therefore let Simplicio be good enough to produce all the specific arguments, experiments, and observations, both physical and astronomical, by which one may be fully persuaded that the earth differs from the celestial bodies, is immovable, and is located in the center of the universe, or anything else that would exclude the earth from being movable like a planet such as Jupiter, or the moon, etc. And you, Salviati, have the kindness to reply step by step.

SIMP. For a beginning, then, here are two powerful demonstrations proving the earth to be very different from celestial bodies. First, bodies that are generable corruptible, alterable, etc., are quite different from those that are ingenerable, incorruptible, inalterable, etc. The earth is generable, corruptible, alterable, etc., while celestial bodies are ingenerable, incorruptible, inalterable, etc. Therefore the earth is very different from the celestial bodies.

SAGR. With your first argument, you bring back to the table what has been standing there all day and has just now been carried away.

SIMP. Softly, sir; hear the rest, and you will see how different it is from that. Formerly the minor premise was proved *a priori*, and now I wish to prove it *a posteriori*. See for yourself whether this is the same thing. I shall prove the minor, because the major is obvious.

Sensible experience shows that on earth there are continual generations, corruptions, alterations, etc., the like of which neither our senses nor the traditions or memories of our ancestors have ever detected in heaven; hence heaven is inalterable, etc., and the earth alterable, etc., and therefore different from the heavens.

The second argument I take from a principal and essential property, which is this: whatever body is naturally dark and devoid of light is different from luminous and resplendent bodies; the earth is dark and without light, and celestial bodies are splendid and full of light; therefore, etc. Answer these, so that too great a pile does not accumulate, and then I will add others.

SALV. As to the first, for whose force you appeal to experience, I wish you would tell me precisely what these alterations are that you see on the earth and not in the heavens, and on account of which you call the earth alterable and the heavens not.

SIMP. On earth I continually see herbs, plants, animals generating and decaying; winds, rains, tempests, storms arising; in a word, the appearance of the earth undergoing perpetual change. None of these changes are to be discerned in celestial bodies, whose positions and configurations correspond exactly with everything men remember, without the generation of anything new there or the corruption of anything old.

SALV. But if you have to content yourself with these visible, or rather these seen experiences, you must consider China and America celestial bodies, since you surely have never seen in them these alterations which you see in Italy. Therefore, in your sense, they must be

inalterable.

SIMP. Even if I have never seen such alterations in those places with my own senses, there are reliable accounts of them; besides which, *cum eadem sit ratio totius et partium*, those countries being a part of the earth like ours, they must be alterable like this.

SALV. But why have you not observed this, instead of reducing yourself to having to believe the tales of others? Why not see it with your own eyes?

SIMP. Because those countries are far from being exposed to view; they are so distant that our sight could not discover such alterations in them.

SALV. Now see for yourself how you have inadvertently revealed the fallacy of your argument. You say that alterations which may be seen near at hand on earth cannot be seen in America because of the great distance. Well, so much the less could they be seen in the moon, which is many hundreds of times more distant. And if you believe in alterations in Mexico on the basis of news from there, what reports do you have from the moon to convince you that there are no alterations there? From your not seeing alterations in heaven (where if any occurred you would not be able to see them by reason of the distance, and from whence no news is to be had), you cannot deduce that there are none, in the same way as from seeing and recognizing them on earth you correctly deduce that they do exist here.

SIMP. Among the changes that have taken place on earth I can find some so great that if they had occurred on the moon they could yet well have been observed here below. From the oldest records we have it that formerly, at the Straits of Gibraltar, Abila and Calpe were joined together with some lesser mountains which held the ocean in check; but these mountains being separated by some cause, the opening admitted the sea, which flooded in so as to form the Mediterranean. When we consider the immensity of this, and the difference in appearance which must have been made in the water and land seen from afar, there is no doubt that such a change could easily have been seen by anyone then on the moon. Just so would the inhabitants of earth have discovered any such alteration in the moon; yet there is no history of such a thing being seen. Hence there remains no basis for saying that anything in the heavenly bodies is alterable, etc.

SALV. I do not make bold to say that such great changes have taken place in the moon, but neither am I sure that they could not have happened. Such a mutation could be represented to us only by some variation between the lighter and the darker parts of the moon, and I doubt whether we have had observant selenographers on earth who have for any considerable number of years provided us with such exact selenography as would make us reasonably conclude that no such change has come about in the face of the moon. Of the moon's appearance, I find no more exact description than that some say it represents a human face; others, that it is like the muzzle of a lion; still others, that it is Cain with a bundle of thorns on his back. So to say "Heaven is inalterable, because neither in the moon nor in other celestial bodies are such alterations seen as are discovered upon the earth" has no power to prove anything.

SAGR. This first argument of Simplicio's leaves me with another haunting doubt which I should like to have removed. Accordingly I ask him whether the earth was generable and corruptible before the Mediterranean inundation, or whether it began to be so then?

SIMP. It was without doubt generable and corruptible before, as well; but that was so vast a

mutation that it might have been observed as far as the moon.

SAGR. Well, now; if the earth was generable and corruptible before that flood, why may not the moon be equally so without any such change? Why is something necessary in the moon which means nothing on the earth?

SALV. A very penetrating remark. But I am afraid that Simplicio is altering the meaning a bit in this text of Aristotle and the other Peripatetics. They say that they hold the heavens to be inalterable because not one star there has ever been seen to be generated or corrupted, such being probably a lesser part of heaven than a city is of the earth; yet innumerable of the latter have been destroyed so that not a trace of them remains.

SAGR. Really, I thought otherwise, believing that Simplicio distorted this exposition of the text so that he might not burden the Master and his disciples with a notion even more fantastic than the other. What folly it is to say, "The heavens are inalterable because stars are not generated or corrupted in them." Is there perhaps someone who has seen one terrestrial globe decay and another regenerated in its place? Is it not accepted by all philosophers that very few stars in the heavens are smaller than the earth, while a great many are much bigger? So the decay of a star in heaven would be no less momentous than for the whole terrestrial globe to be destroyed! Now if, in order to be able to introduce generation and corruption into the universe with certainty, it is necessary that as vast a body as a star must be corrupted and regenerated, then you had better give up the whole matter; for I assure you that you will never see the terrestrial globe or any other integral body in the universe so corrupted that, after having been seen for many ages past, it dissolves without leaving a trace behind.

SALV. But to give Simplicio more than satisfaction, and to reclaim him if possible from his error, I declare that we do have in our age new events and observations such that if Aristotle were now alive, I have no doubt he would change his opinion. This is easily inferred from his own manner of philosophizing, for when he writes of considering the heavens inalterable, etc., because no new thing is seen to be generated there or any old one dissolved, he seems implicitly to let us understand that if he had seen any such event he would have reversed his opinion, and properly preferred the sensible experience to natural reason. Unless he had taken the senses into account, he would not have argued immutability from sensible mutations not being seen.

SIMP. Aristotle first laid the basis of his argument *a priori*, showing the necessity of the inalterability of heaven by means of natural, evident, and clear principles. He afterward supported the same *a posteriori*, by the senses and by the traditions of the ancients.

SALV. What you refer to is the method he uses in writing his doctrine, but I do not believe it to be that with which he investigated it. Rather, I think it certain that he first obtained it by means of the senses, experiments, and observations, to assure himself as much as possible of his conclusions. Afterward he sought means to make them demonstrable. That is what is done for the most part in the demonstrative sciences; this comes about because when the conclusion is true, one may by making use of analytical methods hit upon some proposition which is already demonstrated, or arrive at some axiomatic principle; but if the conclusion is false, one can go on forever without ever finding any known truth -- if indeed one does not encounter some impossibility or manifest absurdity. And you may be sure that Pythagoras, long before he discovered the proof for which he sacrificed a hecatomb, was sure that the square on the side opposite the right angle in a right triangle was equal to the squares on the other two sides. The certainty of a conclusion assists not a little in the discovery of its proof -- meaning always in

the demonstrative sciences. But however Aristotle may have proceeded, whether the reason a priori came before the sense perception *a posteriori* or the other way round, it is enough that Aristotle, as he said many times, preferred sensible experience to any argument. Besides, the strength of the arguments *a priori* has already been examined.

Now, getting back to the subject, I say that things which are being and have been discovered in the heavens in our own time are such that they can give entire satisfaction to all philosophers, because just such events as we have been calling generations and corruptions have been seen and are being seen in particular bodies and in the whole expanse of heaven. Excellent astronomers have observed many comets generated and dissipated in places above the lunar orbit, besides the two new stars of 1572 and 1604, which were indisputably beyond all the planets. And on the face of the sun itself, with the aid of the telescope, they have seen produced and dissolved dense and dark matter, appearing much like the clouds upon the earth: and many of these are so vast as to exceed not only the Mediterranean Sea, but all of Africa, with Asia thrown in. Now, if Aristotle had seen these things, what do you think he would have said and done, Simplicio?

SIMP. I do not know what would have been done or said by Aristotle, who was the master of all science, but I know to some extent what his followers do and say, and what they ought to do and say in order not to remain without a guide, a leader, and a chief in philosophy.

As to the comets, have not these modern astronomers who wanted to make them celestial been vanquished by the *Anti-Tycho*? Vanquished, moreover, by their own weapons; that is, by means of parallaxes and of calculations turned about every which way, and finally concluding in favor of Aristotle that they are all elemental. A thing so fundamental to the innovators having been destroyed, what more remains to keep them on their feet?

SALV. Calm yourself, Simplicio. What does this modern author of yours say about the new stars of 1572 and 1604, and of the solar spots? As far as the comets are concerned I, for my part, care little whether they are generated below or above the moon, nor have I ever set much store by Tycho's verbosity. Neither do I feel any reluctance to believe that their matter is elemental, and that they may rise as they please without encountering any obstacle from the impenetrability of the Peripatetic heavens, which I hold to be far more tenuous, yielding, and subtle than our air. And as to the calculation of parallaxes, in the first place I doubt whether comets are subject to parallax; besides, the inconstancy of the observations upon which they have been computed renders me equally suspicious of both his opinions and his adversary's -- the more so because it seems to me that the *Anti-Tycho* sometimes trims to its author's taste those observations which do not suit his purposes, or else declares them to be erroneous.

SIMP. With regard to the new stars, the *Anti-Tycho* thoroughly disposes of them in a few words, saying that such recent new stars are not positively known to be heavenly bodies, and that if its adversaries wish to prove any alterations and generations in the latter, they must show us mutations made in stars which have already been described for a long time and which are celestial objects beyond doubt. And this can never possibly be done.

As to that material which some say is generated and dissolved on the face of the sun, no mention is made of it at all, from which I should gather that the author takes it for a fable, or for an illusion of the telescope, (note: The telescope was an object of suspicion in many circles.) or at best for some phenomenon produced by the air; in a word, for anything but celestial matter.

SALV. But you, Simplicio, what have you thought of to reply to the opposition of these

importunate spots which have come to disturb the heavens, and worse still, the Peripatetic philosophy? It must be that you, as its intrepid defender, have found a reply and a solution which you should not deprive us of.

SIMP. I have heard different opinions on this matter. Some say, "They are stars which, like Venus and Mercury, go about the sun in their proper orbits, and in passing under it present themselves to us as dark; and because there are many of them, they frequently happen to collect together, and then again to separate." Others believe them to be figments of the air; still others, illusions of the lenses; and still others, other things. But I am most inclined to believe -- yes, I think it certain -- that they are a collection of various different opaque objects, coming together almost accidentally; and therefore we often see that in one spot there can be counted ten or more such tiny bodies of irregular shape that look like snowflakes, or tufts of wool, or flying moths. They change places with each other, now separating and now congregating, but mostly right under the sun, about which, as their center, they move. But it is not therefore necessary to say that they are generated or decay. Rather, they are sometimes hidden behind the body of the sun; at other times, though far from it, they cannot be seen because of their proximity to its immeasurable light. For in the sun's eccentric sphere there is established a sort of onion composed of various folds, one within another, each being studded with certain little spots, and moving; and although their movements seem at first to be inconstant and irregular, nonetheless it is said to be ultimately observed that after a certain time the same spots are sure to return. This seems to me to be the most appropriate expedient that has so far been found to account for such phenomena, and at the same time to maintain the incorruptibility and ingenerability of the heavens. And if this is not enough, there are more brilliant intellects who will find better answers.

SALV. If what we are discussing were a point of law or of the humanities, in which neither true nor false exists, one might trust in subtlety of mind and readiness of tongue and in the greater experience of the writers, and expect him who excelled in those things to make his reasoning most plausible, and one might judge it to be the best. But in the natural sciences, whose conclusions are true and necessary and have nothing to do with human will, one must take care not to place oneself in the defense of error; for here a thousand Demostheneses and a thousand Aristotles would be left in the lurch by every mediocre wit who happened to hit upon the truth for himself. Therefore, Simplicio, give up this idea and this hope of yours that there may be men so much more learned, erudite, and well-read than the rest of us as to be able to make that which is false become true in defiance of nature. And since among all opinions that have thus far been produced regarding the essence of sunspots, this one you have just explained appears to you to be the correct one, it follows that all the rest are false. Now to free you also from that one -- which is an utterly delusive chimera -- I shall, disregarding the many improbabilities in it, convey to you but two observed facts against it.

One is that many of these spots are seen to originate in the middle of the solar disc, and likewise many dissolve and vanish far from the edge of the sun, a necessary argument that they must be generated and dissolved. For without generation and corruption, they could appear there only by way of local motion, and they all ought to enter and leave by the very edge.

The other observation, for those not in the rankest ignorance of perspective, is that from the changes of shape observed in the spots, and from their apparent changes in velocity, one must infer that the spots are in contact with the sun's body, and that, touching its surface, they are moved either with it or upon it and in no sense revolve in circles distant from it. Their motion proves this by appearing to be very slow around the edge of the solar disc, and quite fast toward its center; the shapes of the spots prove the same by appearing very narrow around the

sun's edge in comparison with how they look in the vicinity of the center. For around the center they are seen in their majesty and as they really are; but around the edge, because of the curvature of the spherical surface, they show themselves foreshortened. These diminutions of both motion and shape, for anyone who knows how to observe them and calculate diligently, correspond exactly to what ought to appear if the spots are contiguous to the sun, and hopelessly contradict their moving in distant circles, or even at small intervals from the solar body. This has been abundantly demonstrated by our mutual friend in his *Letters to Mark Welser on the Solar Spots*. It may be inferred from the same changes of shape that none of these are stars or other spherical bodies, because of all shapes only the sphere is never seen foreshortened, nor can it appear to be anything but perfectly round. So if any of the individual spots were a round body, as all stars are deemed to be, it would present the same roundness in the middle of the sun's disc as at the extreme edge, whereas they so much foreshorten and look so thin near that extremity, and &e on the other hand so broad and long toward the center, as to make it certain that these are flakes of little thickness or depth with respect. to their length and breadth.

Then as to its being observed ultimately that the same spots are sure to return after a certain period, do not believe that, Simplicio; those who said that were trying to deceive you. That this is so, you may see from their having said nothing to you about those that are generated or dissolved on the face of the sun far from the edge; nor told you a word about those which foreshorten, this being a necessary proof of their contiguity to the sun. The truth about the same spots returning is merely what is written in the said *Letters*; namely, that some of them are occasionally of such long duration that they do not disappear in a single revolution around the sun, which takes place in less than a month.

SIMP. To tell the truth, I have not made such long and careful observations that I can qualify as an authority on the facts of this matter; but certainly I wish to do so, and then to see whether I can once more succeed in reconciling what experience presents to us with what Aristotle teaches. For obviously two truths cannot contradict one another.

SALV. Whenever you wish to reconcile what your senses show you with the soundest teachings of Aristotle, you will have no trouble at all. Does not Aristotle say that because of the great distance, celestial matters cannot be treated very definitely?

SIMP. He does say so, quite clearly.

SALV. Does he not also declare that what sensible experience shows ought to be preferred over any argument, even one that seems to be extremely well founded? And does he not say this positively and without a bit of hesitation?

SIMP. He does.

SALV. Then of the two propositions, both of them Aristotelian doctrines, the second -- which says it is necessary to prefer the senses over arguments -- is a more solid and definite doctrine than the other, which holds the heavens to be inalterable. Therefore it is better Aristotelian philosophy to say "Heaven is alterable because my senses tell me so," than to say, "Heaven is inalterable because Aristotle was so persuaded by reasoning. Add to this that we possess a better basis for reasoning about celestial things than Aristotle did. He admitted such perceptions to be very difficult for him by reason of the distance from his senses, and conceded that one whose senses could better represent them would be able to philosophize about them with more certainty. Now we, thanks to the telescope, have brought the heavens

thirty or forty times closer to us than they were to Aristotle, so that we can discern many things in them that he could not see; among other things these sunspots, which were absolutely invisible to him. Therefore we can treat of the heavens and the sun more confidently than Aristotle could.

SAGR. I can put myself in Simplicio's place and see that he is deeply moved by the overwhelming force of these conclusive arguments. But seeing on the other hand the great authority that Aristotle has gained universally; considering the number of famous interpreters who have toiled to explain his meanings; and observing that the other sciences, so useful and necessary to mankind, base a large part of their value and reputation upon Aristotle's credit; Simplicio is confused and perplexed, and I seem to hear him say, "Who would there be to settle our controversies if Aristotle were to be deposed? What other author should we follow in the schools, the academies, the universities? What philosopher has written the whole of natural philosophy, so well arranged, without omitting a single conclusion? Ought we to desert that structure under which so many travelers have recuperated? Should we destroy that haven, that Prytaneum (note: Greek public hall where statesmen, heroes, and dignitaries were honored and entertained.) where so many scholars have taken refuge so comfortably; where, without exposing themselves to the inclemencies of the air, they can acquire a complete knowledge of the universe by merely turning over a few pages? Should that fort be leveled where one may abide in safety against all enemy assaults?"

I pity him no less than I should some fine gentleman who, having built a magnificent palace at great trouble and expense, employing hundreds and hundreds of artisans, and then beholding it threatened with ruin because of poor foundations, should attempt, in order to avoid the grief of seeing the walls destroyed, adorned as they are with so many lovely murals; or the columns fall, which sustain the superb galleries, or the gilded beams; or the doors spoiled, or the pediments and the marble cornices, brought in at so much cost -- should attempt, I say, to prevent the collapse with chains, props, iron bars, buttresses, and shores.

SALV. Well, Simplicio need not yet fear any such collapse; I undertake to insure him against damage at a much smaller cost. There is no danger that such a multitude of great, subtle, and wise philosophers will allow themselves to be overcome by one or two who bluster a bit. Rather, without even directing their pens against them, by means of silence alone, they place them in universal scorn and derision. It is vanity to imagine that one can introduce a new philosophy by refining this or that author, It is necessary first to teach the reform of the human mind and to render it capable of distinguishing truth from falsehood, which only God can do.

But where have we strayed, going from one argument to another? I shall not be able to get back to the path without guidance from your memory.

SIMP. I remember quite well. We were dealing with the reply of the *Anti-Tycho* to the objections against the immutability of the heavens. Among these you brought in this matter of the sunspots, not mentioned by its author, and I believe you wished to give consideration to his reply in the case of the new stars.

SALV. Now I remember the rest. Continuing this subject, it seems to me that in the counter argument of the *Anti-Tycho* there are some things that ought to be criticized. First of all, if the two new stars, which that author can do no less than place in the highest regions of heaven, and which existed a long time and finally vanished, caused him no anxiety about insisting upon the inalterability of heaven simply because they were not unquestionably parts of heaven or mutations in the ancient stars, then to what purpose does he make all this fuss and bother

about getting the comets away from the celestial regions at all costs? Would it not have been enough for him to say that they are not unquestionably parts of heaven and not mutations in the ancient stars, and hence that they do not prejudice in any way either the heavens or the doctrines of Aristotle?

In the second place I am not satisfied about his state of mind when he admits that any alterations which might be made in the stars would be destructive of the celestial prerogatives of incorruptibility, etc., since the stars are celestial things, as is obvious and as everybody admits, and when on the other hand he is not the least perturbed if the same alterations take place elsewhere in the expanse of heaven outside the stars themselves. Does he perhaps mean to imply that heaven is not a celestial thing? I should think that the stars were called celestial things because of their being in the heavens, or because of their being made of heavenly material, and that therefore the heavens would be even more celestial than they; I could not say similarly that anything was more terrestrial than earth itself, or more igneous than fire.

Next, his not having made mention of the sunspots, which are conclusively proved to be produced and dissolved and to be situated next to the body of the sun and to revolve with it or in relation to it, gives me a good indication that this author may write more for the comforting of others than from his own convictions. I say this because he shows himself to be acquainted with mathematics, and it would be impossible for him not to be convinced by the proofs that such material is necessarily contiguous to the sun and undergoes generations and dissolutions so great that nothing of comparable size has ever occurred on earth. And if the generations and corruptions occurring on the very globe of the sun are so many, so great, and so frequent, while this can reasonably be called the noblest part of the heavens, then what argument remains that can dissuade us from believing that others take place on the other globes?

SAGR. I cannot without great astonishment -- I might say without great insult to my intelligence -- hear it attributed as a prime perfection and nobility of the natural and integral bodies of the universe that they are invariant, immutable, inalterable, etc., while on the other hand it is called a great imperfection to be alterable, generable, mutable, etc. For my part I consider the earth very noble and admirable precisely because of the diverse alterations, changes, generations, etc. that occur in it incessantly. If, not being subject to any changes, it were a vast desert of sand or a mountain of jasper, or if at the time of the flood the waters which covered it had frozen, and it had remained an enormous globe of ice where nothing was ever born or ever altered or changed, I should deem it a useless lump in the universe, devoid of activity and, in a word, superfluous and essentially nonexistent. This is exactly the difference between a living animal and a dead one; and I say the same of the moon, of Jupiter, and of all other world globes.

The deeper I go in considering the vanities of popular reasoning, the lighter and more foolish I find them. What greater stupidity can be imagined than that of calling jewels, silver, and gold "precious," and earth and soil "base"? People who do this ought to remember that if there were as great a scarcity of soil as of jewels or precious metals, there would not be a prince who would not spend a bushel of diamonds and rubies and a cartload of gold just to have enough earth to plant a jasmine in a little pot, or to sow an orange seed and watch it sprout, grow, and produce its handsome leaves, its fragrant flowers, and fine fruit. It is scarcity and plenty that make the vulgar take things to be precious or worthless; they call a diamond very beautiful because it is like pure water, and then would not exchange one for ten barrels of water. Those who so greatly exalt incorruptibility, inalterability, etc. are reduced to talking this way, I believe, by their great desire to go on living, and by the terror they have of death. They do not reflect that if men were immortal, they themselves would never have come into the world.

Such men really deserve to encounter a Medusa's head which would transmute them into statues of jasper or of diamond, and thus make them more perfect than they are.

SALV. Maybe such a metamorphosis would not be entirely to their disadvantage, for I think it would be better for them not to argue than to argue on the wrong side.

SIMP. Oh, there is no doubt whatever that the earth is more perfect the way it is, being alterable, changeable, etc., than it would be if it were a mass of stone or even a solid diamond, and extremely hard and invariant. But to the extent that these conditions bring nobility to the earth, they would render less perfect the celestial bodies, in which they would be superfluous. For the celestial bodies -- that is, the sun, the moon, and the other stars, Which are ordained to have no other use than that of service to the earth -- need nothing more than motion and light to achieve their end.

SAGR. Has nature, then, produced and directed all these enormous, perfect, and most noble celestial bodies, invariant, eternal, and divine. for no other purpose than to serve the changeable, transitory, and mortal earth? To serve that which you call the dregs of the universe, the sink of all uncleanness? Now to what purpose would the celestial bodies be made eternal, etc. in order to serve something transitory, etc.? Take away this purpose of serving the earth, and the innumerable host of celestial bodies is left useless and superfluous, since they have not and cannot have any reciprocal activities among themselves, all of them being inalterable, immutable, and invariant. For instance, if the moon is invariant, how would you have the sun or any other star act upon it? The action would doubtless have no more effect than an attempt to melt a large mass of gold by looking at it or by thinking about it. Besides, it seems to me that at such times as the celestial bodies are contributing to the generations and alterations on the earth, they too must be alterable. Otherwise I do not see how the influence of the moon or sun in causing generations on the earth would differ from placing a marble statue beside a woman and expecting children from such a union.

SIMP. Corruptibility, alteration, mutation, etc. do not pertain to the whole terrestrial globe, which as to its entirety is no less eternal than the sun or moon. But as to its external parts it is generable and corruptible, and it is certainly true that generations and corruptions are perpetual in those parts, and, as perpetual, that they require celestial and eternal operations. Therefore it is necessary that celestial bodies be eternal.

SAGR. This is all very well, but if there is nothing prejudicial to the immortality of the entire terrestrial globe in the corruptibility of its superficial parts, and if this generability, corruptibility, alterability, etc. give to it a great ornament and perfection, then why can you not and should you not likewise admit alterations, generations, etc. in the external parts of the celestial globes, adding these as an ornament without diminishing their perfection or depriving them of actions; even increasing those by making them operative not only upon the earth but reciprocally among themselves, and the earth also upon them?

SIMP. This cannot be, because the generations, mutations, etc. which would occur, say, on the moon, would be vain and useless, and nature makes nothing in vain.

SAGR. And why should they be vain and useless?

SIMP. Because we plainly see and feel that all generations, changes, etc. that occur on earth are either directly or indirectly designed for the use, comfort, and benefit of man. Horses are born to accommodate men; for the nutriment of horses, the earth produces hay and the clouds

water it. For the comfort and nourishment of men are created herbs, cereals, fruits, beasts, birds, and fishes. In brief, if we proceed to examine and weigh carefully all these things, we shall find that the goal toward which all are directed is the need, the use, the comfort and the delight of men. Now of what use to the human race could generations ever be which might happen on the moon or other planets? Unless you mean that there are men also on the moon who enjoy their fruits; an idea which if not mythical is impious.

SAGR. I do not know nor do I suppose that herbs or plants or animals similar to ours are propagated on the moon, or that rains and winds and thunderstorms occur there as on the earth; much less that it is inhabited by men. Yet I still do not see that it necessarily follows that since things similar to ours are not generated there, no alterations at all take place, or that there cannot be things there that do change or are generated and dissolve; things not only different from ours, but so far from our conceptions as to be entirely unimaginable by us.

I am certain that a person born and raised in a huge forest among wild beasts and birds, and knowing nothing of the watery element, would never be able to frame in his imagination another world existing in nature differing from his, filled with animals which would travel without legs or fast beating wings, and not upon its surface alone like beasts upon the earth, but everywhere within its depths; and not only moving, but stopping motionless wherever they pleased, a thing which birds in the air cannot do. And that men lived there too, and built palaces and cities, and traveled with such ease that without tiring themselves at all they could proceed to far countries with their families and households and whole cities. Now as I say, I am sure that such a man could not, even with the liveliest imagination, ever picture to himself fishes, the ocean, ships, fleets, and armadas. Thus, and more so, might it happen that in the moon, separated from us by so much greater an interval and made of materials perhaps much different from those on earth, substances exist and actions occur which are not merely remote from but completely beyond all our imaginings, lacking any resemblance to ours and therefore being entirely unthinkable. For that which we imagine must be either something already seen or a composite of things and parts of things seen at different times; such are sphinxes, sirens, chimeras, centaurs, etc.

SALV. Many times have I given rein to my fancies about these things, and my conclusion is that it is indeed possible to discover some things that do not and cannot exist on the moon, but none which I believe can be and are there, except very generally; that is, things occupying it, acting and moving in it, perhaps in a very different way from ours, seeing and admiring the grandeur and beauty of the universe and of its Maker and Director and continually singing encomiums in His praise. I mean, in a word, doing what is so frequently decreed in the Holy Scriptures; namely, a perpetual occupation of all creatures in praising God.

SAGR. These are among the things which, speaking very generally, could be there. But I should like to hear you mention those which you believe cannot be there, as it must be possible for you to name them more specifically.

SALV. I warn you, Sagredo, that this will be the third time we have thus strayed imperceptibly, step by step, from our principal topic, and we shall get to the point of our argument but slowly if we make digressions. Therefore it will perhaps be good if we defer this matter, along with others we have agreed to put off until a special session.

SAGR. Please, now that we are on the moon, let us go on with things that pertain to it, so that we shall not have to make another trip over so long a road....

[Salviati, using data from telescopic observations, describes the features of the moon and its resemblance to earth: it is spherical, mountainous, and has areas of contrasting brightness. Simplicio argues that the moon is a perfectly smooth sphere made of celestial matter. The three engage in an extended argument about the nature of the moon.]

SIMP. Therefore, in your opinion, the earth would make an appearance similar to that which we see in the moon, of at most two parts. But do you believe then that those great spots which are seen on the face of the moon are seas, and the brighter balance land, or some such thing?

SALV. What you are now asking me is the first of the differences that I think exist between the moon and the earth, which we had better hurry along with, as we are staying too long on the moon. I say then that if there were in nature only one way for two surfaces to be illuminated by the sun so that one appears lighter than the other, and that this were by having one made of land and the other of water, it would be necessary to say that the moon's surface was partly terrene and partly aqueous. But because there are more ways known to us that could produce the same effect, and perhaps others that we do not know of, I shall not make bold to affirm one rather than another to exist on the moon.

We have already seen that a bleached silver plate changes from white to dark by the touch of the burnisher; the watery part of the earth looks darker than the dry; on the ridges of mountains the wooded parts look much gloomier than the open and barren places because the plants cast a great deal of shadow while the clearings are lighted by the sun. Such a mixture of shadows is so effective that in sculptured velvet the color of the cut silk looks much darker than that of the uncut, because of shadows cast between one thread and another; and plain velvet is likewise much darker than taffeta made of the same silk. So if on the moon there were things resembling dense forests, their aspect would probably be like that of the spots we see; a like difference would be created if they were seas; and, finally, there is nothing to prevent these spots being really of a darker color than the rest, for it is in that way that snow makes mountains appear brighter.

What is clearly seen in the moon is that the darker parts are all plains, with few rocks and ridges in them, though there are some. The brighter remainder is all fill of rocks, mountains, round ridges, and other shapes, and in particular there are great ranges of mountains around the spots. That the spots are flat surfaces we are certain, from observing that the boundary which separates the light and dark parts makes an even cut in traversing the spots, whereas in the bright parts it looks broken and jagged. But I do not know whether this evenness of surface is enough by itself to cause the apparent darkness, and I rather think not.

Quite apart from this, I consider the moon very different from the earth. Though I fancy to myself that its regions are not idle and dead, still I do not assert that life and motion exist there, and much less that plants, animals, or other things similar to ours are generated there. Even if they were, they would be extremely diverse, and far beyond all our imaginings. I am inclined to believe this because in the first place I think that the material of the lunar globe is not land and water, and this alone is enough to prevent generations and alterations similar to ours. But even supposing land and water on the moon, there are in any case two reasons that plants and animals similar to ours would not be produced there.

The first is that the varying aspects of the sun are so necessary for our various species that these could not exist at all without them. Now the behavior of the sun toward the earth is much different from that which it displays toward the moon. As to daily illumination, we on the earth have for the most part twenty -- four hours divided between day and night, but the same

effect takes a month on the moon. The annual sinking and rising by which the sun causes the various seasons and the inequalities of day and night are finished for the moon in a month. And whereas for us the sun rises and sinks so much that between its maximum and minimum altitudes there lie forty -- seven degrees of difference (that is, as much as the distance between the tropics), for the moon it varies no more than ten degrees or a little less, which is the amount of the maximum latitudes of its orbit with respect to the ecliptic.

Now think what the action of the sun would be in the torrid zone if for fifteen days without pause it continued to beat down with its rays. It goes without saying that all the plants and herbs and animals would be destroyed; hence if any species existed there, they would be plants and animals very different from present ones.

In the second place, I am sure that there are no rains on the moon, because if clouds collected in any part of it, as around the earth, they would hide some of the things on the moon that we see with the telescope. Briefly, the scene would alter in some respect; an effect which I have never seen during long and diligent observations, having always discovered a very pure and uniform serenity.

SAGR. To this it might be replied that either there might be great dews or that it rains there during its nights; that is, when the sun does not light it up.

SALV. If from other appearances we had any signs that there were species similar to ours there, and only the occurrence of rains was lacking, we should be able to find this or some other condition to take their place, as happens in Egypt by the inundations of the Nile. But finding no event whatever like ours, of the many that would be required to produce similar effects, there is no point in troubling to introduce one only, and even that one not from sure observation but because of mere possibility. Besides, if I were asked what my basic knowledge and natural reason told me regarding the production there of things similar to or different from ours, I should always reply, "Very different and entirely unimaginable by us"; for this seems to me to fit with the richness of nature and the omnipotence of the Creator and Ruler.

SAGR. It always seems to me extreme rashness on the part of some when they want to make human abilities the measure of what nature can do. On the contrary, there is not a single effect in nature, even the least that exists, such that the most ingenious theorists can arrive at a complete understanding of it. This vain presumption of understanding everything can have no other basis than never understanding anything. For anyone who had experienced just once the perfect understanding of one single thing, and had truly tasted how knowledge is accomplished, would recognize that of the infinity of other truths he understands nothing.

SALV. Your argument is quite conclusive; in confirmation of it we have the evidence of those who do understand or have understood some thing; the more such men have known, the more they have recognized and freely confessed their little knowledge. And the wisest of the Greeks, so adjudged by the oracle, said openly that he recognized that he knew nothing.

SIMP. It must be said, then, that either the oracle or Socrates himself was a liar, the former declaring him the wisest, and the latter saying he knew himself the most ignorant.

SALV. Neither of your alternatives follows, since both pronouncements can be true. The oracle judges Socrates wisest above all other men, whose wisdom is limited; Socrates recognizes his knowing nothing relative to absolute wisdom which is infinite. And since much is the same part of infinite as little, or as nothing (for to arrive at an infinite number it makes no difference

whether we accumulate thousands, tens, or zeros), Socrates did well to recognize his limited knowledge to be as nothing to the infinity which he lacked. But since there is nevertheless some knowledge to be found among men, and this is not equally distributed to all, Socrates could have had a larger share than others and thus have verified the response of the oracle.

SAGR. I think I understand this point quite well. Among men there exists the power to act, Simplicio, but it is not equally shared by all; and no doubt the power of an emperor is greater than that of a private person, but both are nil in comparison to Divine omnipotence. Among men there are some who understand agriculture better than others; but what has knowing how to plant a grapevine in a ditch got to do with knowing how to make it take root, draw nourishment, take from this some part good for building leaves, some other for forming tendrils, this for the bunches, that for the grapes, the other for the skins, all this being the work of most wise Nature? This is one single particular example of the innumerable works of Nature, and in this alone may be recognized an infinite wisdom; hence one may conclude that Divine wisdom is infinitely infinite.

SALV. Here is another example. Do we not say that the art of discovering a beautiful statue in a block of marble has elevated the genius of Michelangelo far, far above the ordinary minds of other men? Yet this work is nothing but the copying of a single attitude and position of the external and superficial members of one motionless man. Then what is it in comparison with a man made by Nature, composed of so many members, external and internal, of so many muscles, tendons, nerves, bones, that serve so many and such diverse motions? And what shall we say of the senses, of spiritual power, and finally of the understanding? May we not rightly say that the making of a statue yields by an infinite amount to the formation of a live man, even to the formation of the lowest worm?

SAGR. And what difference do you think there was between the dove of Archytas and a natural dove?

SIMP. Either I am without understanding or there is a manifest contradiction in this argument of yours. Among your greatest encomiums, if not indeed the greatest of all, is your praise for the understanding which you attribute to natural man. A little while ago you agreed with Socrates that his understanding was nil. Then you must say that not even Nature understood how to make an intellect that could understand.

SALV. You put the point very sharply, and to answer the objection it is best to have recourse to a philosophical distinction and to say that the human understanding can be taken in two modes, the *intensive* or the *extensive*. *Extensively*, that is, with regard to the multitude of intelligibles, which are infinite, the human understanding is as nothing even if it understands a thousand propositions; for a thousand in relation to infinity is zero. But taking man's understanding *intensively*, in so far as this term denotes understanding some proposition perfectly, I say that the human intellect does understand some of them perfectly, and thus in these it has as much absolute certainty as Nature itself has. Of such are the mathematical sciences alone; that is, geometry and arithmetic, in which the Divine intellect indeed knows infinitely more propositions, since it knows all. But with regard to those few which the human intellect does understand, I believe that its knowledge equals the Divine in objective certainty, for here it succeeds in understanding necessity, beyond which there can be no greater sureness.

SIMP. This speech strikes me as very bold and daring.

SALV. These are very ordinary propositions and far from any shade of temerity or boldness.

They do not detract in the least from the majesty of Divine wisdom, just as saying that God cannot undo what is done does not in the least diminish His omnipotence. But I question, Simplicio, whether your suspicion does not arise from your having taken my words equivocally. So in order to explain myself better, I say that as to the truth of the knowledge which is given by mathematical proofs, this is the same that Divine wisdom recognizes; but I shall concede to you indeed that the way in which God knows the infinite propositions of which we know some few is exceedingly more excellent than ours. Our method proceeds with reasoning by steps from one conclusion to another, while His is one of simple intuition. We, for example, in order to win a knowledge of some properties of the circle (which has an infinity of them), begin with one of the simplest, and, taking this for the definition of circle, proceed by reasoning to another property, and from this to a third, and then a fourth, and so on; but the Divine intellect, by a simple apprehension of the circle's essence, knows without time-consuming reasoning all the infinity of its properties. Next, all these properties are in effect virtually included in the definitions of all things; and ultimately, through being infinite, are perhaps but one in their essence and in the Divine mind. Nor is all the above entirely unknown to the human mind either, but it is clouded with deep and thick mists, which become partly dispersed and clarified when we master some conclusions and get them so firmly established and so readily in our possession that we can run over them very rapidly. For, after all, what more is there to the square on the hypotenuse being equal to the squares on the other two sides, than the equality of two parallelograms on equal bases and between parallel lines? And is this not ultimately the same as the equality of two surfaces which when superimposed are not increased, but are enclosed within the same boundaries? Now these advances, which our intellect makes laboriously and step by step, run through the Divine mind like light in an instant; which is the same as saying that everything is always present to it.

I conclude from this that our understanding, as well in the manner as in the number of things understood, is infinitely surpassed by the Divine; but I do not thereby abase it so much as to consider it absolutely null. No, when I consider what marvelous things and how many of them men have understood, inquired into, and contrived, I recognize and understand only too clearly that the human mind is a work of God's, and one of the most excellent.

SAGR. I myself have many times considered in the same vein what you are now saying, and how great may be the acuteness of the human mind. And when I run over the many and marvelous inventions men have discovered in the arts as in letters, and then reflect upon my own knowledge, I count myself little better than miserable. I am so far from being able to promise myself, not indeed the finding out of anything new, but even the learning of what has already been discovered, that I feel stupid and confused, and am goaded by despair. If I look at some excellent statue, I say within my heart: "When will you be able to remove the excess from a block of marble and reveal so lovely a figure hidden therein? When will you know how to mix different colors and spread them over a canvas or a wall and represent all visible objects by their means, like a Michelangelo, a Raphael, or a Titian?" Looking at what men have found out about arranging the musical intervals and forming precepts and rules in order to control them for the wonderful delight of the ear, when shall I be able to cease my amazement? What shall I say of so many and such diverse instruments? With what admiration the reading of excellent poets fills anyone who attentively studies the invention and interpretation of concepts And what shall I say of architecture? What of the art of navigation?

But surpassing all stupendous inventions, what sublimity of mind was his who dreamed of finding means to communicate his deepest thoughts to any other person, though distant by mighty intervals of place and time! Of talking with those who are in India; of speaking to those who are not yet born and will not be born for a thousand or ten thousand years; and with

what facility, by the different arrangements of twenty characters upon a page!

Let this be the seal of all the admirable inventions of mankind and the close of our discussions for this day. The honest hours now being past, I think that Salviati might like to enjoy our cool ones in a gondola; and tomorrow I shall expect you both so that we may continue the discussions now begun.

End of the First Day

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