

SAGR. I am easily convinced that the air can take the clouds along with it, they being of material which is very tractable by reason of its lightness and its lack of any contrary tendency; indeed, they are of a material which shares in the qualities and properties of the earth. But birds, being animate, can also move contrary to the diurnal motion; and that the air can restore this to them once they have interrupted it seems problematical to me, especially since they are solid and heavy bodies. As was said before, we see rocks and other heavy bodies remain defiant to the impetus of the wind, and when they do give in to it they are never moved with any such speed as that of the wind which pushes them.

SALV. Let us not grant to the moving air so little force, Sagredo; it is able to drive heavily laden ships and to uproot trees and to overthrow towers when it moves swiftly. Yet in such violent actions as these, its motion cannot be said by a long way to be as fast as the diurnal rotation.

SIMP. You see, then; moving air will be able to keep up the motion of projectiles also, in accordance with Aristotle's teaching. It did seem strange to me that he should have erred in this particular.

SALV. It certainly would be able to do so if it could keep up its own motion. But just as ships stop and trees cease to bend when the wind slackens, so the motion of the air does not keep on after the stone has left the hand and the arm is stopped. Hence it remains true that something besides the air makes the projectile move.

SIMP. What do you mean, the ship stops when the wind slackens? It is often seen that the wind has stopped, and the sails have even been furlled, and yet the vessel continues to travel for miles on end.

SALV. This argues against you, Simplicio, if the air, which by carrying the sails propels the ship, is stopped, and without help of any kind from the medium the ship continues its course.

SIMP. It might be said that the water was the medium which propelled the ship and maintained its motion.

SALV. Well, that certainly might be said, but it would be the exact opposite of the truth. For the truth is that the water has such a strong resistance to being separated by the ship's hull that it works against this with much foaming and does not let the ship

receive a large part of that velocity which the wind would confer upon it if the hindrance of the water were not there. You must never have considered, Simplicio, the fury with which the water strikes against a boat when, rapidly driven by oars or by the wind, the boat runs through still water: if you had paid attention to this effect you would not have thought up such a silly idea now. I see that you have hitherto been one of that herd who, in order to learn how matters such as this take place, and in order to acquire a knowledge of natural effects, do not betake themselves to ships or crossbows or cannons, but retire into their studies and glance through an index and a table of contents to see whether Aristotle has said anything about them; and, being assured of the true sense of his text, consider that nothing else can be known.

SAGR. Happy are they, and much to be envied for this. For if a knowledge of everything is naturally desired, and if being informed is the same thing as taking credit for being informed, then they enjoy a very great knowledge. They can persuade themselves that they know and understand everything, in complete defiance of those who recognize their own ignorance of what they do not know. These latter, perceiving that they know only the tiniest portion of what is knowable, exhaust themselves in waking and studying, and mortify themselves with experiments and observations.

But please let us return to our birds, with regard to which you have said that the air, moving very speedily, can restore that part of the diurnal movement which they may have lost in the sportings of their flight. To this I reply that the moving air does not seem able to confer upon a solid and heavy body so much as its own velocity, and since that of the air is that of the earth, it does not appear that the air would be sufficient to supply the deficit of that lost by the birds in flight.

SALV. Your argument puts up an appearance of much probability, and your doubt is not one that is raised by ordinary intelligences; yet outside of its appearance, I do not believe that essentially it has a bit more force than those already considered and disposed of.

SAGR. There is not the slightest doubt that unless it is rigorously conclusive, it is absolutely ineffective; for it is only when a conclusion is inescapable that no worthwhile argument can be produced against it.

A great joy,
much to be en-
vied, is that of
people who
think they know
everything.

SARV. Your having more trouble with this objection than with the others seems to me to depend upon birds being animate, and thereby being able to use force at will against the original inherent motion of terrestrial objects. In just the same way, we see them fly upward when they are alive; a motion impossible to them as heavy bodies, so that when dead they can only fall downward. From this you assume that the causes which hold for all other sorts of projectiles previously discussed cannot hold for birds. Well, this is true enough, Sagredo; and because it is true we do not see other projectiles do what birds do; for if you drop a dead bird and a live one from the top of a tower, the dead one will do the same as a stone; that is, it will follow first the general diurnal motion, and then the motion downward, being heavy. But as to the live bird, the diurnal motion always remaining in it, what is to prevent it from sending itself by the beating of its wings to whatever point of the compass it pleases? And such a new motion being its own, and not being shared by us, it must make itself noticeable. If the bird moves off toward the west in its flight, what is there to prevent it from returning once more to the tower by means of a similar beating of its wings? For after all, its leaving toward the west in flight was nothing but the subtraction of a single degree from, say, ten degrees of diurnal motion, so that nine degrees remain to it while it is flying. And if it alighted on the earth, the common ten would return to it; to this it could add one by flying toward the east, and with the eleven it could return to the tower. In sum, when we consider well and reflect more closely upon the effects of flight in birds, these do not differ in any way from those of projectiles directed toward any part of the earth, except that the latter are moved by an external source and the former by an internal principle.

For a final indication of the nullity of the experiments brought forth, this seems to me the place to show you a way to test them all very easily. Shut yourself up with some friend in the main cabin below decks on some large ship, and have with you there some flies, butterflies, and other small flying animals. Have a large bowl of water with some fish in it; hang up a bottle that empties drop by drop into a wide vessel beneath it. With the ship standing still, observe carefully how the little animals fly with equal speed to all sides of the cabin. The fish swim indifferently in all directions; the drops fall into the vessel beneath;

Experiment which alone shows the nullity of all those aduced against the motion of the earth.

Argument taken from the flight of birds against the earth's motion is resolved.

and, in throwing something to your friend, you need throw it no more strongly in one direction than another, the distances being equal; jumping with your feet together, you pass equal spaces in every direction. When you have observed all these things carefully (though there is no doubt that when the ship is standing still everything must happen in this way), have the ship proceed with any speed you like, so long as the motion is uniform and not fluctuating this way and that. You will discover not the least change in all the effects named, nor could you tell from any of them whether the ship was moving or standing still. In jumping, you will pass on the floor the same spaces as before, nor will you make larger jumps toward the stern than toward the prow even though the ship is moving quite rapidly, despite the fact that during the time that you are in the air the floor under you will be going in a direction opposite to your jump. In throwing something to your companion, you will need no more force to get it to him whether he is in the direction of the bow or the stern, with yourself situated opposite. The droplets will fall as before into the vessel beneath without dropping toward the stern, although while the drops are in the air the ship runs many spans. The fish in their water will swim toward the front of their bowl with no more effort than toward the back, and will go with equal ease to bait placed anywhere around the edges of the bowl. Finally the butterflies and flies will continue their flights indifferently toward every side, nor will it ever happen that they are concentrated toward the stern, as if tired out from keeping up with the course of the ship, from which they will have been separated during long intervals by keeping themselves in the air. And if smoke is made by burning some incense, it will be seen going up in the form of a little cloud, remaining still and moving no more toward one side than the other. The cause of all these correspondences of effects is the fact that the ship's motion is common to all the things contained in it, and to the air also. That is why I said you should be below decks; for if this took place above in the open air, which would not follow the course of the ship, more or less noticeable differences would be seen in some of the effects noted. No doubt the smoke would fall as much behind as the air itself. The flies likewise, and the butterflies, held back by the air, would be unable to follow the ship's motion if they were separated from it by a perceptible distance. But keeping them-

selves near it, they would follow it without effort or hindrance; for the ship, being an unbroken structure, carries with it a part of the nearby air. For a similar reason we sometimes, when riding horseback, see persistent flies and horseflies following our horses, flying now to one part of their bodies and now to another. But the difference would be small as regards the falling drops, and as to the jumping and the throwing it would be quite imperceptible.

SAGR. Although it did not occur to me to put these observations to the test when I was voyaging, I am sure that they would take place in the way you describe. In confirmation of this I remember having often found myself in my cabin wondering whether the ship was moving or standing still; and sometimes at a whim I have supposed it going one way when its motion was the opposite. Still, I am satisfied so far, and convinced of the worthlessness of all experiments brought forth to prove the negative rather than the affirmative side as to the rotation of the earth.

Now there remains the objection based upon the experience of seeing that the speed of whirling has a property of extruding and discarding material adhering to the revolving frame. For that reason it has appeared to many, including Ptolemy,[†] that if the earth turned upon itself with great speed, rocks and animals would necessarily be thrown toward the stars, and buildings could not be attached to their foundations with cement so strong that they too would not suffer similar ruin.

SALV. Before coming to the solution of this objection, I cannot help mentioning something I have noticed many times, and not without amusement. It occurs in nearly everyone who hears for the first time of the earth's motion. Such people so firmly believe the earth to be motionless that not only do they have no doubt of its being at rest, but they really believe that everyone else has always agreed with them in thinking it to have been created immovable and kept so in all past ages. Rooted in this idea, they are stupefied to hear that someone grants it to have motion, as if such a person, after having held it to be motionless, foolishly imagined it to have been set in motion when Pythagoras (or whoever it was) first said that it moved, and not before. Now that a silly idea like this, of supposing that those who admit the earth's motion believe it first to have been stable, from its creation up to the time of Pythagoras, and then made movable only after

[†]Stupidity of some who think the earth to have begun to move when Pythagoras commented saying that it moved.

Pythagoras deemed it to be so, should find a place in the giddy minds of common people is no marvel to me; but that the Aristotles and the Ptolemies should also have fallen into this puerility truly seems to me strange and inexcusable simple-mindedness. SAGR. Then you believe, Salvatrat, that Ptolemy thought he needed to support the stability of the earth only by arguments directed against people who concede it to have been immovable up to the time of Pythagoras, and who affirm it to have been made movable only when Pythagoras attributed motion to it?

SALV. I cannot help believing so, when we consider well the attitude he takes in refuting their proposition. His refutation is to be found in the demolition of buildings and the flinging of stones, animals, and men themselves toward the sky. Now such ruin and havoc could not be visited upon edifices and animals unless these existed on the earth in the first place, and men could not be located or edifices built upon the earth unless it was standing still. So it is obvious that Ptolemy is arguing against those who, having granted quiescence to the earth for some time — that is, while animals and stones and masons could remain on it and build palaces and cities — suddenly make it movable afterward, to the ruin and destruction of the buildings, animals, etc. For if he had undertaken to dispute with those who attributed a whirling to the earth ever since its original creation, he would have refuted them by saying that if the earth had always moved, there never could have been beasts or men or stones upon it; much less buildings erected, cities founded, etc.

SIMP. I am not convinced of any Aristotelian or Ptolemaic impropriety here.

SALV. Ptolemy argues either against those who considered the earth always movable or against those who thought it to be stable for a time and then to be set in motion. If against the former, he ought to have said: "The earth has not always moved, for there would never have been men nor animals nor edifices on earth, the terrestrial whirling having not permitted them to stay." But since his reasoning is, "The earth does not move, because beasts and men and buildings placed on the earth would be precipitated from it," he assumes the earth to have been once in that state which would have allowed beasts and men to stay and build them. From this the conclusion is drawn that the earth has been fixed at some time; that is, adapted to the stay of animals and the building of edifices. Now do you understand what I mean?

Aristotle and Ptolemy appear to have refuted the earth's mobility against those who would believe that, having stood still a long time, it began to move in Pythagoras's time.