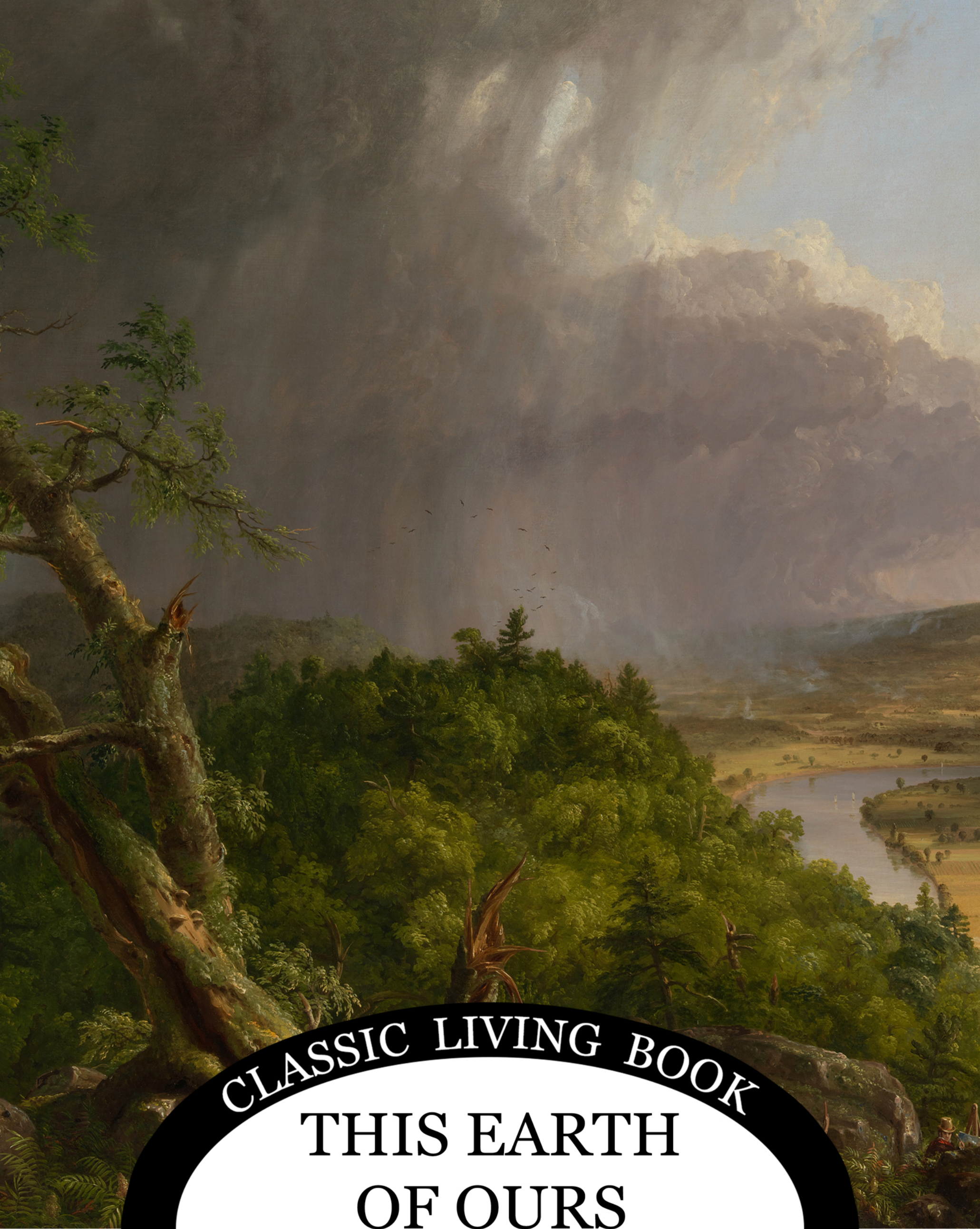

CLASSIC LIVING BOOK

THIS EARTH OF OURS

Jean-Henri Fabre

COMPLETE AND UNABRIDGED

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by

Jean-Henri Fabre

LIVING BOOK PRESS

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TRANSLATOR'S PREFACE

In this book we have "Uncle Paul" speaking in his own proper person; but though the dialogue form is discarded the style remains unchanged - as genially familiar and anecdotal as in the earlier volumes of the series.

No more pleasing presentation of the main facts of physical geography - or physiography, as it is now more commonly called - could be desired than is to be found in the following chapters. Especially interesting, even thrilling, are the accounts of early mountain-climbing in the Alps and in the Pyrenees - of the first ascent of Mont Blanc and Ramond's attempted ascent of Mont Perdu. The perils of polar exploration area as so vividly portrayed, and the wonders of glaciers and geysers, the terrors of volcanoes and earthquakes, and the beauties of coral islands, with much else that young readers and also their elders are sure to enjoy, will here be found set forth in the author's characteristic manner and with his wonted clearness and charm.

One further comment is called for here. Our genial author had a way of repeating himself, perhaps on the principle that one can never have too much of a good thing. Now and then a passage of greater or less length occurring in an earlier book will be found reprinted without change in one or more later books, with no apology from the author and no indication that the passage in question has already appeared elsewhere. In the present volume this eccentricity has been suppressed so far as it has been found possible to suppress it without undue mutilation of the book. What little of repetition remains will, it is hoped, be agreeably reminiscent rather than fatiguingly trite.

INTRODUCTION

This volume of the elementary science series gives a general account of the earth on which we live. Its object is to impart a little agreeable diversion to the unavoidable dryness of geography, and thus to make interesting a useful branch of learning that has too often been looked upon as devoid of interest.

In a series of familiar talks, the simplicity of which will not detract from the irresistible charm of the subject, I propose to bring within the understanding of all readers the great questions that ought to form the basis of geographical studies, but that are nearly always sacrificed in favor of a dry list of names of countries, towns, rivers, etc., having no attraction whatever for the inquiring mind. Doubtless it is well to know where on the map to find Kaffraria and Zanzibar; but it is still better to have correct ideas of the earth as a whole, the earth as God made it, with its double movement of rotation and revolution giving us our days and our seasons, with its central furnace in which continents are forged, and with its atmosphere and seas whence all life derives sustenance. It is not enough, it seems to me, to learn by rote from a geography book that a volcano is a smoking mountain, that a sea is a large body of water, that an earthquake is a trembling of the ground under our feet, and that a glacier is a valley full of snow and ice. One ought also to know in brief the mechanism of these great, natural forces and the part they play in the general scheme of things, for such studies are of inestimable worth in their power to uplift the soul and ennoble the mind by showing forth the stupendous marvels of creation.

J. H. FABRE.

CHAPTER I

THE TERRESTRIAL GLOBE

A CELEBRATED author, Bernardin de Saint-Pierre, tells us the strange notion he had, in his childhood, of the earth and sky. Judging from appearances, he thought the sun rose from behind one mountain and set behind another. He regarded the sky as a blue vault or inverted bowl resting on the outer edge of the earth, so that if he should ever manage to reach that edge it would be necessary, he imagined, to walk in a stooping posture so as not to bump his head against the firmament. One day, determined to remain no longer in doubt, he undertook to make the thing sure. Some lunch was put up for him in a basket, and he set off. He walked and walked for a long time, in the hope of soon touching the sky with his hand; but the vault, receding as he advanced, was always the same distance away, until at last fatigue overcame him and he abandoned the expedition. But, though he retraced his steps, he was still persuaded of the reality of the celestial vault; his failure to reach it and touch it being easily explained: his legs were not long enough and strong enough to carry him the necessary distance.

You, my readers, may at one time have shared this childish error and imagined the earth to be an extended tract of land broken up by mountains and covered with the blue cupola of the sky; but now you are well aware that nowhere does the sky rest on the ground, nowhere does one run the risk of bumping one's head against the firmament, because the blue sky is of the same height everywhere. You also know that by walking straight ahead you come to plains, mountains, seas, but never to any barriers marking the ends of the earth. In short, you have learned that the earth is round and that if you should continue in the same direction long enough you would finally get back to your starting-point.

The earth is an immense globe floating unsupported in space. Imagine a large ball suspended in the air by a thread, and on this ball a gnat. If this gnat should take a notion to go all over the surface, is it not true that it could come and go over the ball, above, below, on the side, without ever encountering an obstacle, without ever seeing a barrier rise up to block its passage? Is it not equally true that if it always kept on in the same direction, the gnat would end by making the tour of the ball and would come back to its starting-point? So it is with us on the surface of the earth, though we are far more insignificant when compared with the globe that bears us than is the tiniest gnat in comparison with the biggest ball you can imagine. Without ever encountering a barrier, without ever touching the cupola of the sky, we come and go in a thousand different directions, we accomplish the most distant journeys, even make the tour of the earth and return to our starting-point. The earth, then, is round; it is an immense ball that floats without support in celestial space. As to the blue vault that arches above us, it is a mere appearance caused by the blue color of the air enveloping the earth on all sides.[1]

The earth is round, as proved by the following facts. When, in order to reach the town he is journeying toward, a traveler crosses a level plain where nothing intercepts his view, from a certain distance the highest points of the town, the summits of towers and steeples, are seen first. From a lesser distance the spires of the steeples become entirely visible, then the roofs of buildings, and finally the buildings themselves; so that the view embraces a great number of objects, beginning with the highest and ending with the lowest, as the distance diminishes. This would not be so if the earth were flat. At any distance a tower, instead of becoming gradually visible from top to bottom, would be seen as a whole the moment it became visible

1 This paragraph and some subsequent ones are repeated from *The Story Book of Science*. See "Translator's Preface."

at all, as illustrated in Figure 1, which shows two observers, A and B, at very different distances from the tower at the left, but both able to see it in its full extent. On the other hand, if the ground is curved, if the earth is round, objects sufficiently far off will be hidden by the curvature of the earth's surface; and as the distance lessens they will appear by degrees, beginning with the top. Thus, to an observer at A in Figure 2, the tower is quite invisible because the curvature of the ground obstructs the view. To an observer at B the upper half of the tower is visible, while the lower half is still hidden by the curvature of the earth. Finally, when the observer arrives at the point C, the whole tower is in plain sight.

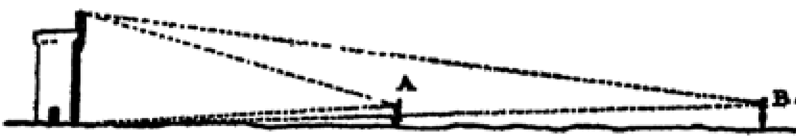

FIGURE 1

On dry land it is rare to find a surface that in extent and regularity is adapted to the observation I have just told you about. Nearly always hills, ridges, or masses of foliage intercept the view and prevent the gradual appearance, from summit to base, of the tower or steeple that one is approaching. On the sea no obstacle bars the view unless it be the convexity of the water, which follows the general curvature of the earth's surface. It is, accordingly, there especially that it is easy to study the phenomena produced by the rounded form of the earth.

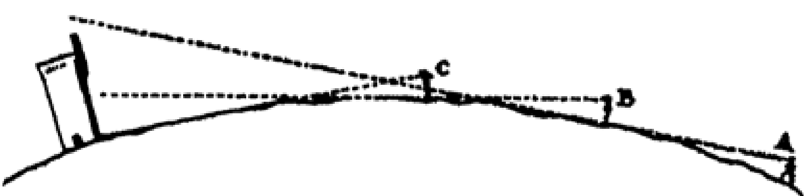

FIGURE 2

When a ship coming from the open sea approaches the coast, the first points of the shore visible to those on board are the highest points, like the summits of mountains. Later the tops of high towers come into view, then the edge of the shore itself. In the same way, an observer who watches from the shore the arrival of a vessel sees first the tops of the masts, then the topsails, then the sails next below, and finally the hull of the vessel. If the vessel were departing from the shore, the observer would see it gradually disappear and apparently sink into the water, all in reverse order; that is, the hull would be first hidden from view, then the low sails, then the high ones, and finally the top of the mainmast, which would be the last to disappear, as shown in Figure 3.

FIGURE 3

Another proof of the earth's roundness is found in the shape of the horizon. This term, taken from the Greek word meaning "to bound," is applied to the line all around us that bounds the view when one is in the open country.

It is at this line that the sky appears to join the earth. Now, on a plain, with no unevenness of ground to mar its regularity, the horizon forms a circle whose center is the observer. The circular shape of the horizon is still more marked at sea, the surface of the water presenting the appearance of a vast disk whose outline merges with the blue of the sky. If the earth were flat, our view of its surface would be limited only by the strength of our eyesight, and with a powerful enough telescope we could see almost any distance, so that there would be no boundary between the visible and the invisible portion of the earth's surface. But in reality the case is quite different: against the barrier of the horizon even the best telescopes are powerless. Hence, the earth is not flat, but round. All this will be made clear by Figure 4.

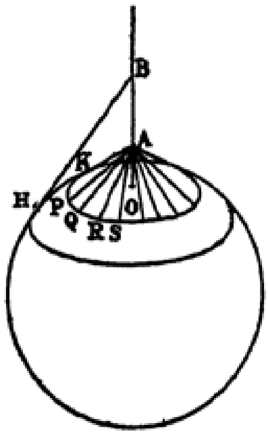

Figure 4

On the sphere there depicted, imagine a straight line, OB, erected, perpendicular to the surface at the point of erection. If from the point A in this line the gaze be directed all around, what portion of the sphere will be seen? The answer is easily arrived at. From A let us draw a straight line, AK, grazing the surface of the sphere at K. This straight line will serve to represent the line of vision. All between the observer and the point K where the line touches the sphere is evidently visible, while all beyond that point is invisible. If, from A, similar lines, AP, AQ, AR, AS, etc., are drawn all about the point A so as to graze the surface, each of these lines at its point of contact with the sphere will mark another point on the horizon, and all these points taken together will, if we suppose them to be infinite in number, evidently form an unbroken circle. The same result would be attained from any other point of observation. Hence, if the horizon is circular wherever it is viewed, the earth must be a sphere.

Now, this enormous globe that we call the earth is forty million meters, or ten thousand leagues, in circumference. What these numbers mean will perhaps be made clearer to you if you will follow me a little farther. If you have ever happened to climb a high tower and cast a look over the surrounding expanse, you have been struck with the great extent of territory offered to your view; and the bluish line of the horizon has seemed so far away as to remain in your mind as the best example of great distance. How far away from you really was the horizon? How far could you see from the top of the tower? That depends on two things: the height of the tower and the evenness or the unevenness of the ground. Let us look again at the figure and, instead of imagining the observer's eye at A, imagine it higher, as at B. It is clear that from this latter point the line of vision will graze the sphere's surface at a greater distance, as at H, thus giving a wider horizon. So it is that, on account of the earth's roundness, the higher you are above its surface the farther you can see.

On the other hand, the unevenness of a mountainous region cuts off the view and so restricts the horizon. Suppose, then, the ground to be even like the surface of the sea, and the place of observation to be as high as the loftiest belfry in the world, that of Strasbourg Cathedral, which is 142 meters above the pavement; under these conditions the horizon would be ten leagues from the observer. If another Bernardin de Saint-Pierre, equipped with a sturdy pair of legs, wished to reach the horizon seen from the Strasbourg Cathedral's belfry, it would be a day's walk for him; and if he succeeded in accomplishing this, he might not have the courage and the strength to start out again the next day. Well, so huge is this earth of ours that its circumference measures a thousand times ten leagues, a thousand times as far as one can see from the loftiest belfry in the world.

You have probably asked yourself by this time how it is that the earth can be said to have a rounded surface when there are so many vast mountain chains and deep valleys to break the regularity of that surface. You are willing to admit that the ocean surface is evenly curved, but the dry land, you maintain, is quite different. You see nothing but irregularity there. What indication is there, you ask, of regular curvature in this jumble of mountains, valleys, hills, plains, and precipices? How can one trace any systematic plan in ground full of these enormous irregularities? But, let me ask in turn, is an orange round? Yes, certainly, you reply. Look at it carefully, however: the skin is all wrinkled. No matter, you say; the orange is round, for the wrinkles in its skin are as nothing compared with the size of the fruit. Exactly; and so I say, in my turn, that the earth is round despite all the inequalities of its surface, because the very highest mountains are as nothing in comparison with its immense size. And I will prove it to you.

Let the earth be represented by a large, smooth ball, two meters in diameter; then, in their right proportions, picture in relief on its surface some of the principal mountains of the globe. The highest of these is Mount Everest, of the Himalayan chain in central Asia. Its granite summit towers 8,840 meters[2] above the level of the sea, being so high that it is seldom wrapped in clouds, while its base covers the space of an empire. What is man, physically considered, in face of such a giant? Well, let us represent this giant on our large ball that we imagine to be the earth. Do you know what we should need for this purpose? A tiny grain of sand that would slip through your fingers, a grain of sand 1 1/3 millimeters through! The gigantic mountain that overwhelms us with its immensity is a mere nothing when compared with the earth. The tiniest pimple on an orange is incomparably larger in comparison with the fruit. The highest mountain of Europe, Mont Blanc, which is 4,810 meters high, would be represented by a grain of sand having about half the diameter of the other. But we need not multiply these examples. You see clearly enough that by sprinkling grains of sand thus over the surface of the ball to represent the various inequalities in the earth's surface we should not really change the general shape of our ball. The earth, then, is only a larger ball strewn with grains of dust and sand proportioned to its size and known as hills and mountains.

How is the earth held poised in space? Is it suspended by some celestial chain to the vault of the firmament, as the sanctuary lamp to the vault of the temple? Or does it rest on some support, as a geographical globe on its pedestal…! Thousands of travelers have journeyed over it in all directions and have nowhere seen either suspending chain or supporting pedestal of any sort. Everywhere, as here in our own country, their view encounters only earth, air, and sea. So we must conclude that this globe of ours is isolated in space, that it swims in a void without support.

Why, then, does it not fall? Ah, that is the problem! But think a moment and perhaps you will see why the earth cannot fall. What do you see overhead? The open sky, boundless space. What would you see if you were on the opposite side of the earth, standing on the spot that we think of as directly under

2 That is, 29,002 feet, or nearly 5 ½ miles. The meter is equivalent to 29.37011 inches – *Translator*.

our feet? Still the open sky and boundless space. And on the spot halfway around the earth to the right or to the left? Still the same, always the same. Thus everywhere the open sky, which is the same as boundless space, surrounds the earth. Now tell me, in what direction in this space, which is the same in every direction, is the earth to fall? Tell me, if you can, which way is up and which way is down. If "up" is toward the sky, remember that the sky is also on the opposite side of the earth, that it is just the same there as here, and that it is the same everywhere. If it seems to you plain enough that the earth cannot leap up into the sky that is above us, why should you expect it to leap into the sky that is beneath us? To fall toward that sky would be to rise in the same sense that we say an arrow rises here when it is shot upward. You have never wondered why the earth does not rise toward the firmament; so do not wonder why it does not fall, for these two are one and the same.

All this will be further explained in the next chapter, in which we shall consider the cause of the fall of bodies. But first let us sum up the principal points of this chapter. The earth is round and isolated in space. It is forty million meters or ten million leagues in circumference. Its semi-diameter, or the distance from its center to its surface, is 6,366 kilometers, or a little less than 1,600 leagues. The greatest inequalities in its surface are as nothing compared with its size and do not appreciably modify its spherical shape.

CHAPTER II

THE FALL OF BODIES

WHO DOES not know the delightful fable of "The Acorn and the Pumpkin," and who is there that has not laughed at Garo's misadventure? A good man at heart, but a little pretentious, Garo the cottager thought that the pumpkin, instead of lying idly on its stomach on the ground, would be better hanging from the branches of the oak in place of the acorn. That would be just the thing, such a fruit for such a tree! While thus criticizing the works of God and taking no little satisfaction in being able to give good advice to the Creator, Garo fell asleep under an oak.

> But (rude awakening from sweet repose)
> An acorn fell and hit him on the nose.
> The injured member straight began to bleed,
> And this our Garo could not fail to heed.
> "Oh, oh!" he cried, in quite another key,
> "I wonder what would have become of me
> If there had fallen, in the acorn's place,
> A heavy pumpkin plump upon my face.
> But, heaven be praised, God did not will it so;
> And God was right, that much I've learned to know."

And you, my young readers, will agree with Garo. If the oak bore pumpkins for fruit, who would ever dare to seek its perilous shade?

If the fall of an acorn taught Garo that what is done by God is well done, the fall of an apple showed Newton that God does everything according to number, weight, and measure, and that from all time he has regulated the movements of the celestial bodies by admirable mechanical laws. Newton, who had one of the keenest intellects ever known, was walking in his youth through an apple orchard, when an apple fell to the ground. You would have picked it up and eaten it, and that would have been the end of the matter. But Newton asked himself why it had fallen. Foolish question! You would have told him that it fell because, being overripe, it had become detached from the branch. But wait a moment. First answer my questions, and then perhaps you will admit that it is not so easy to brush aside the young thinker's query.

The apple fell from the top of the apple tree. Would it have fallen just the same if the apple tree had been as tall as a poplar? Yes, undoubtedly. Would it have fallen if the tree had been ten times or a hundred times as tall? Why not? We know very well that a stone falls from the top of a tower and from the summit of a mountain. Finally, would it have fallen if by some miracle the tree had grown so tall as to bear fruit at the height of a league? Yes, again, for balloons rise as high and even higher, and objects thrown out by the balloonist never fail to come back to the earth. And would the apple still have fallen from a height of ten, a hundred, or a thousand leagues? Well, you hesitate? There is nothing to hesitate about; however high you imagine the apple, it must still fall. Indeed, the greater the elevation, the faster will the fall finally become.

You and I, then, are agreed in this: though the branches of the apple tree tower above the clouds or even become lost in the depths of the firmament, the apples will always fall to the ground. But tell me; if the apple were replaced by a leaden ball, would this likewise fall to earth? Certainly, you reply; the leaden ball, being heavier than the apple, would fall so much the better, no matter from what height. Very well, then; according to you, an apple, and still more a leaden ball, must fall to earth from any height whatever. And there you reason well, for if a body falls from a given height nothing can prevent its falling from a still greater height. I even think the ball of lead would fall were it as far off as the moon. What do you think about it? This requires reflection. Yet, after all, if there is nothing in the way, why should it not fall? Yes, you say, it will fall.

And now I have caught you. The next moonlit night raise your eyes to the sky. Do you see, away up there, that enormous luminous ball unsupported by anything? Take care! According to what you have just told me, it will fall on our heads and crush us in its frightful descent. That immense ball, the moon, is a globular mass of matter equal to the fiftieth part of the terrestrial globe. Ah, bah! you exclaim; the moon fall! Yes, my young readers, the moon does actually fall; and there we have the problem that caused Newton to reflect under the apple tree. The moon falls, and if it ever reached us it would put an end to every one of us and to this poor old earth of ours, which would be shattered to fragments under the terrific shock of the heavenly body fallen from the firmament. The moon is always falling; but don't be alarmed: despite its continual fall toward the earth it always keeps at the same distance from us, which must seem to you the strangest sort of paradox. Let us, then, proceed at once to the preliminary studies that will give us an explanation of this incredible fact.

I pick up a stone; I open my hand and the stone falls, returning to the ground. Any other object, as a piece of wood, an iron ball, a drop of water, a leaden bullet, would do the same. But there are certain substances that, instead of falling toward the ground, rise and remain suspended at great heights; and among these are smoke, clouds, and balloons. Have we here a real exception to the rule that a body when left to itself falls to the ground, or is the suspension of these bodies in the air due to some cause that impedes the operation of the general law? A piece of wood held in the hand falls to the ground when released; but if, instead of standing on the earth's surface, we were immersed at a great depth in water, the piece of wood when released would not fall. Although obedient to the law of falling bodies, it would rise, on escaping from our grasp, and would return to the surface of the water; instead of descending it would ascend, because it is lighter than the water in which it is immersed.

Well, here on the earth's surface we are really on the floor of an immense ocean; we are at the bottom of the atmosphere, an ocean of air enveloping the earth on all sides. Accordingly, smoke and clouds, being lighter than the surrounding air, must rise from the bottom of the atmospheric ocean just as wood does from the bottom of the ocean of water. But if there were no air, then smoke, clouds, and balloons would not rise; everything, absolutely everything, would fall just as lead falls. And what is more, in the absence of air all bodies would fall with the same rapidity. Light down and heavy lead, stone, wood, cork, metals — all these, though of so different natures and varying weight, one from another, would reach the ground together if dropped from the same height at the same instant. A hundred-kilogram ball of lead would not go any faster in its fall than a tuft of thistledown. Here again I read in your wondering looks the signs of utter incredulity. What, you exclaim, a piece of paper, a feather, or a bit of cotton would fall as fast as a ball of lead? Nonsense! You are joking. If from an upper window we drop a leaden ball and a piece of paper at the same time, we know very well that the ball will reach the ground first and the paper will float about for some time before settling down. Agreed, I reply; but before you accuse me of error let us go over again together the experiment you propose with such assurance of triumph, according to your way of thinking.

In my turn I tell you that if the ball of metal reaches the ground before the paper, air is the cause of the difference, on account of the unequal resistance it opposes to the fall of the two bodies. This resistance is great for the paper, which has much surface and very little weight; but it is slight for the metal ball, which has little surface and much weight. Accordingly, the lead, being less impeded in its fall, must come to earth first. In racing over ground covered with dense underbrush, which of two men equally good at running on a hard road would reach the goal first, — the stronger one, who could easily thrust aside the obstructing underbrush, or the weaker one, who could do so only with difficulty? Evidently the former. Lead does the same thing: stronger than paper, or, in other words, heavier than paper, it easily pushes aside the obstacle obstructing its passage. It cleaves the air without difficulty and arrives at the goal first.

Let us return to our two men running through the thicket of underbrush. If the weaker, the second one, instead of having to open a way for himself, ran just behind the stronger one so as to profit by the path opened by his sturdy legs, do you not think he would reach the goal on the very heels of his competitor, being as good a runner as he when no obstacles bar the way? That is clear enough, you say. Well, we are going to make the metal go first and open a way through the aerial underbrush, so to speak. Then you will see the paper rush along this course as fast as the metal. Let us take a large penny or, better still, a five-franc piece, and then with a pair of scissors cut out a round piece of paper of exactly the same size, or even a little smaller, so that its edge shall nowhere project beyond the rim of the coin. We now place this piece of paper on the coin, not pasting it on, you understand, or even wetting it first with saliva. Then, holding both coin and paper in our fingers, with the paper uppermost, we let them fall from a window at some height from the ground. Clink! It is done. Metal and paper reach the earth at the same instant. You can repeat the experiment from any height whatever, even from the top of a lofty tower, and the result will always be the same: the piece of metal and the piece of paper will reach the ground together, unless the metal turns over on the way instead of falling flat, as it started.

It cannot be said that the coin impelled or pushed the paper, since the coin started just ahead of the paper. So if the latter arrives at the goal at the same time as the former, it is because, in falling, it goes as fast as the other; and this it always will do if it meets with no resistance from the air. Hence we conclude that, with no air to offer resistance, all substances fall equally fast. Now that you are convinced of this principle, which at first seemed so strange to you, I hope that another time, before saying a thing is impossible, you will wait for the proof. How many things that seem at first impossible become quite simple upon reflection!

A falling body stops when it reaches the earth, because the solid ground bars its passage. But if the earth were to open and make way for the falling object, offering an empty well of indefinite depth for its passage, whither would it go, toward what point would it move? That is what we must now find out.

Attach a bullet to the end of a long string and you will have what is called a plumb-line or plummet. Take the other end of the string in your hand and let the bullet hang free. After swinging to and fro a number of times it will finally come to rest, and when it is quite motionless the stretched cord will indicate the direction the bullet would take if not held back; for evidently the cord could not oppose its fall and hold it stationary without being itself stretched taut in exactly the direction of the interrupted fall. Therefore, to find the direction that bodies take in falling, we have merely to note the direction indicated by the plummet. Now, if you will observe the position of a plummet over a sheet of still water like that in a wide basin, for example, you will see that in relation to the surface of the water the cord does not slant to either side but is perfectly straight; in a word, it is perpendicular. This direction of the cord is called vertical. A vertical line, then, is one that does not slant toward either side in reference to the surface of still water; or, as it is otherwise put, a vertical line is one that is perpendicular to such a surface. Finally, the surface of still water is called a horizontal surface.

This vertical direction is a matter of much importance in many cases, particularly in our buildings, which would be unstable if the builder were not careful to make sure with his plumb-line that the wall under construction went straight up instead of leaning this way or that. Suppose you wish to find out, for example, whether the corner of a house forms a perfectly vertical line. Stand before this corner with a plummet hanging in front of you from your upraised hand. The corner or edge under inspection should be completely hidden by the plumb-line; otherwise, the edge is not vertical and the house is badly built.

We have just learned that bodies fall perpendicularly in reference to the surface of still water, or, in other words, that they fall vertically. Now, for a water surface we can just as well take that of the sea in a calm as that of a lake or of a basin. In each instance, the falling body descends perpendicularly to the sheet of water. We know that the surface of the sea is rounded — that it follows, with a regularity not to be found elsewhere, the general curvature of the earth — and the same may be said

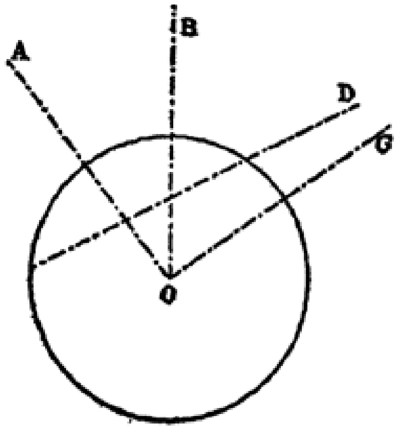

FIGURE 5

of any sheet of water, as that in a lake, or in a basin, or in a bucket. But in these latter instances, the curvature would not be appreciable on account of the small extent of the surface considered. If on the surface of a calm sea and on that of still water in general the fall of bodies is in a direction perpendicular to that surface, what conclusion shall we draw from this? In the accompanying figure, the earth is represented by a circle whose center is at O. Three straight lines, A, B, C, are drawn perpendicularly to the circumference of this circle; that is, in relation to the curve they slant neither to one side nor to the other, and all three, if sufficiently prolonged, meet at the center, O. But the line D, which slants to one side in reference to the contour of the circle, does not go through the center on being prolonged. Therefore, since everywhere bodies fall in a direction perpendicular to the curved surface of water at rest, it is plain that all falling bodies move toward the center of the earth.

What is there at this central point to make all bodies move toward it in their fall? Is there, perhaps, some powerful magnet attracting them, as an ordinary magnet attracts iron? No, there is no kind of magnet that could draw to itself objects of all sorts, no one particular thing that could cause the fall of these bodies. Just what there is at the earth's center we do not clearly know, but certainly the direction followed by falling bodies is not determined by anything at that center. If a body left unsupported falls — that is, if it returns to the ground — it is because the earth attracted it. Now, this attraction is not exerted by any one part of the earth more than by another; it is exerted by all parts equally at the same time, by those to the right, those to the left, those on the surface, and those deep within, all without distinction; and from all these attractions, of which any one acting alone would draw the body in one particular direction, there results a total attraction that directs a falling body toward the center of the earth.

Imagine a two-horse carriage. If the right-hand horse alone is harnessed to it, the carriage will go slantwise toward the right. If the left-hand horse is the one harnessed to the carriage, it will again go slantwise, but this time toward the left. If, however, both horses are harnessed to it in front, the carriage will move straight ahead. Exactly the same thing occurs when a body falls; for we can imagine the earth divided into two perfectly equal parts, one toward the right, the other toward the left of our falling body. If the right-hand half alone exerted its attraction, the body would move toward the right; if only the left-hand attracted it, it would move toward the left. But with the combined attraction of both halves, or of the total mass of the earth, the body takes a middle course and moves toward the earth's center. Consequently, if all falling bodies move toward the center of the earth, it is not on account of any special attraction belonging to this center, but simply because of the symmetrical arrangement of the earth's mass in relation to this point.

Experiment has proved that a falling body moves 4.9 meters[3] in the first second of its fall. A second, as you know, is a very short time, being only the sixtieth part of a minute, which in turn is the sixtieth part of an hour. As a body falls, it moves faster and faster, so that the distance covered in each successive second increases rapidly. This is shown in the following table.

Duration of fall expressed in seconds	Distance covered
1	4.9 meters
2	4 times 4.9 meters
3	9 times 4.9 meters
4	16 times 4.9 meters
5	25 times 4.9 meters

3 Or 16.1 feet, very nearly. – *Translator*.

6	36 times 4.9 meters
7	49 times 4.9 meters
8	64 times 4.9 meters
etc	etc.

Notice that 4 is the product of 2 multiplied by 2, 9 the product of 3 by 3, 16 the product of 4 by 4, 25 the product of 5 by 5, and so on. Therefore, to find how many meters a body falls in any given time, we multiply by itself the number of meters the fall continues, and then multiply this product by 4.9.

You can make a rather interesting application of this rule. Imagine yourself at the top of a tower, or on the edge of a precipice, or looking down into a deep dry well, and you wish to know the height of the tower or of the precipice, or the depth of the well. You take a stone and let it fall to the foot of the tower or of the precipice, or to the bottom of the dry well, counting the seconds that elapse between the dropping of the stone and the sound of its fall. To estimate this time, if you have not a watch that tells the seconds, you can count your pulse beats, which correspond approximately to the ticking of seconds. Let us suppose six seconds to elapse. Multiplying 6 by 6, we have 36, and this multiplied by 4.9 gives the height or the depth desired, or about 176 meters.