

3) In their fall the atoms collide, not because of their differing weights, but because of the *clinamen*. The *clinamen* is the reason for the collision, it relates one atom to another. It is tied in a fundamental manner to the Epicurean theory of time and is an essential part of the system. In the void, all atoms fall with equal velocity: an atom is no more or less rapid with respect to its weight than other atoms which more or less hinder its fall. In the void, the velocity of the atom is equal to its movement *in a unique direction in a minimum of continuous time*. This minimum expresses the smallest possible term during which an atom moves in a given direction, before being able to take another direction as the result of a collision with another atom. There is therefore a minimum of time, no less than a minimum of matter or a minimum of the atom. In agreement with the nature of the atom, this minimum of continuous time refers to the apprehension of thought. It expresses the most rapid or briefest thought: the atom moves "as swiftly as thought."⁵ But, as a result, we must conceive of an originary direction for each atom, as a synthesis which would give to the movement of the atom its initial direction, without which there would be no collision. This synthesis is necessarily accomplished in a time smaller than the minimum of continuous time. This is the *clinamen*. The *clinamen* or swerve has nothing to do with an oblique movement which would come accidentally to modify a vertical fall.⁶ It has always been present: it is not a secondary movement, nor a secondary determination of the movement, which would be produced at any time, at any place. The *clinamen* is the original determination of the direction of the movement of the atom. It is a kind of *conatus*—a differential of matter and, by the same token, a differential of thought, based on the method of exhaustion. The meanings of the terms which qualify it have in fact this origin:

"*incertus*" does not mean indeterminate, but rather unassignable; "*paulum*," "*incerto tempore*," "*intervallo minimo*" mean "in a time smaller than the minimum of continuous, thinkable time."

4) This is why the *clinamen* manifests neither contingency nor indetermination. It manifests something entirely different, the *lex atomi*, that is, the irreducible plurality of causes or of causal series, and the impossibility of bringing causes together into a whole. In fact, the *clinamen* is the determination of the meaning of causal series, where each causal series is constituted by the movement of an atom and conserves in the encounter its full independence. In the well-known discussion which set the Epicureans and Stoics against each other, the problem was not directly relating to contingency and necessity, but rather to causality and destiny. Epicureans and Stoics alike affirm causality (no motion without a cause); but the Stoics wish also to affirm destiny, that is, the unity of causes "among themselves." To this, the Epicureans object that one cannot affirm destiny without also introducing necessity, that is, the absolute linking up of effects with one another. It is true that the Stoics retort that they are not at all introducing necessity, but that the Epicureans, for their part, cannot refuse the unity of causes without falling into contingency and chance.⁷ Thus, the true problem is whether there is a unity of causes *among themselves*. Must the thought of Nature bring causes together into a whole? The big difference between the Epicureans and the Stoics is that they do not enact the same cleavage of the causal relation. The Stoics affirm a difference of nature between corporeal causes and their incorporeal effects. As a result, effects refer to effects and form a *conjugation*, whereas causes refer to causes and form a *unity*. The Epicureans, on the contrary, affirm the independence of the *plurality* of the material causal series, in virtue of a *swerve* which affects each; and it is only in this objective sense that the *clinamen* may be called "chance."

Nor to pursue the atoms one by one,
To see the law whereby each thing goes on.
But some men, ignorant of matter, think,
Opposing this, that not without the gods,
In such adjustment to our human ways,
Can Nature change the seasons of the years,
And bring to birth the grains and all of else
To which divine Delight, the guide of life,
Persuades mortality and leads it on,
That, through her artful blandishments of love,
It propagate the generations still,
Lest humankind should perish. When they feign
That gods have stablished all things but for man,
They seem in all ways mightily to lapse
From reason's truth: for ev'n if ne'er I knew
What seeds primordial are, yet would I dare
This to affirm, ev'n from deep judgment based
Upon the ways and conduct of the skies-
This to maintain by many a fact besides-
That in no wise the nature of the world
For us was builded by a power divine-
So great the faults it stands encumbered with:
The which, my Memmius, later on, for thee
We will clear up. Now as to what remains
Concerning motions we'll unfold our thought.
Now is the place, meseems, in these affairs
To prove for thee this too: nothing corporeal
Of its own force can e'er be upward borne,
Or upward go- nor let the bodies of flames
Deceive thee here: for they engendered are
With urge to upwards, taking thus increase,
Whereby grow upwards shining grains and trees,
Though all the weight within them downward bears.
Nor, when the fires will leap from under round
The roofs of houses, and swift flame laps up
Timber and beam, 'tis then to be supposed
They act of own accord, no force beneath
To urge them up. 'Tis thus that blood, discharged
From out our bodies, spurts its jets aloft
And spatters gore. And hast thou never marked

With what a force the water will disgorge
Timber and beam? The deeper, straight and down,
We push them in, and, many though we be,
The more we press with main and toil, the more
The water vomits up and flings them back,
That, more than half their length, they there emerge,
Rebounding. Yet we never doubt, meseems,
That all the weight within them downward bears
Through empty void. Well, in like manner, flames
Ought also to be able, when pressed out,
Through winds of air to rise aloft, even though
The weight within them strive to draw them down.
Hast thou not seen, sweeping so far and high,
The meteors, midnight flambeaus of the sky,
How after them they draw long trails of flame
Wherever Nature gives a thoroughfare?
How stars and constellations drop to earth,
Seest not? Nay, too, the sun from peak of heaven
Sheds round to every quarter its large heat,
And sows the new-ploughed intervalles with light:
Thus also sun's heat downward tends to earth.
Athwart the rain thou seest the lightning fly;
Now here, now there, bursting from out the clouds,
The fires dash zig-zag- and that flaming power
Falls likewise down to earth.
In these affairs
We wish thee also well aware of this:
The atoms, as their own weight bears them down
Plumb through the void, at scarce determined times,
In scarce determined places, from their course
Decline a little- call it, so to speak,
Mere changed trend. For were it not their wont
Thuswise to swerve, down would they fall, each one,
Like drops of rain, through the unbottomed void;
And then collisions ne'er could be nor blows
Among the primal elements; and thus
Nature would never have created aught.

Lucretius - On the Nature of Things, 50 BCE

Michel Serres, The Birth of Physics, 1980.

PROTOCOL

First model: declination in a fluid medium

Everyone knows, everyone concedes that atomic physics is an ancient doctrine but a contemporary discovery. It is a scientific matter, the science of Perrin, Bohr or Heisenberg; the ancient doctrine is only 'philosophy,' or even poetry. Like history in general, the history of the sciences has a pre-history. Just as there is no mathematics before the Greek miracle, that of Thales or Pythagoras, so there is no physics before the blessed classical age, before what has been called, roughly since Kant and the Enlightenment, the Galilean revolution. During this pre-history, 'philosophy' slumbered. We recognise, I believe, ideologies, religious or otherwise, by their use of the calendar as a dramatic device: before or after the birth of Christ, before or after the foundation of Rome or the first year of the Republic, before or after the establishment of the positivist doctrine, before or after the Galilean revolution. Nothing will ever again be as it was. Here is the metaphysical age; there is the positivist age.

From Cicero to Marx and beyond, down to us, the declination of atoms has been treated as a weakness of the atomic theory. The *clinamen* is an absurdity. A logical absurdity, since it is introduced without justification, the cause of itself before being the cause of all things; a geometrical absurdity, in that the definition that Lucretius gives is incomprehensible and confused; a mechanical absurdity, since it is contrary to the principle of inertia, and would result in perpetual motion; an absurdity of physics in general, since experimentation cannot possibly reveal its existence. No-one has ever seen a heavy body swerve suddenly from its path as it falls. Therefore we are not concerned with science. The *clinamen*, consequently, finds a haven in subjectivity, moving from the world to the soul, from physics to metaphysics, from the theory of inert bodies in free fall to the theory of the free movements of living beings. It is the last secret of the decision of the subject, its *inclination*. Lucretius' text itself points in this direction, speaking soon enough of the will as torn from destiny, and of horses that throw

the lightning path obliquely crossing the rainfall, and shows it *nunc hinc, nunc illinc* (II, 214), now on this side, now on that. And the same rain is taken up again in the definition of declination, *imbris uti guttae*, like the drops of rain. There we have it.

The Birth of Physics

themselves from their stalls at the races. Modern materialists are most unhappy with this rupture in determinism and its reinterpretation as the idealism of a free subject. The entire discussion of indeterminism will subsequently reproduce the classical debate on the subject of the *clinamen* in the domain of the sciences.

On the other hand, the absurdity of such a principle is another proof, and a decisive one this time, of the prehistoric status of Greco-Roman physics. This was not a science of the world, but an impure mixture of metaphysics, political philosophy and musings on individual freedom, projected onto the things themselves. Hence the crude finding of criticism: there was no atomist physics in Antiquity. What is more, no applied sciences in general; and the *clinamen* on which it is based is just an immaterial property of the subject. We must read Lucretius' *De rerum natura* as humanists or philologists, and not as a treatise on physics.

Let us go back to Book II, where declination is introduced. It is characterised primarily by two phrases. *Paulum, tantum quod momen mutatum dicere possis* (II, 219–20): atoms, in free fall in space, deviate from their straight trajectory 'a little, just so much that you can call it a change of movement'. Their deviation is as small as possible, and the alteration in their movement is as small as description allows. Lucretius repeats and redefines this deviation a little further: *nec plus quam minimum* (II, 244), 'no more than the minimum'. Classical editions remark on a rhetorical device in these lines. The thing is so absurd and so far from our experience that the physicist minimises it, as if to hide it. Now, anyone who has ever read any Latin texts on mathematics, and more specifically on differential calculus will recognise here two canonic definitions of the potential infinitely small and the actual infinitely small. This is not an anachronism; the relationship of atomism to the first attempts at infinitesimal calculus is well known. From the outset, Democritus seems to have simultaneously produced a mathematical method of exhaustion and the physical hypothesis of indivisibles. We can see here one of the earliest formulations of what will be called a differential. The *clinamen* is thus a differential, and properly, a fluxion.

On the subject of fluxions, let us examine the atomic cataract in which this infinitely small angular deviation is produced. In the lines which precede it, Lucretius shows that the movement of bodies cannot take place from low to high. The examples he cites are instructive; to explain the movement of fire, he uses liquid models: the flow of blood, the red gush which spurts, the fluidity of water, *umor aquae* (II, 197). In the same way, just prior to the long passage on the *clinamen*, he shows us