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the metaphysics of dust

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I

If everyday experience did not provide us with the many and varied phenomena of dust, it can be assumed that atomism might not have received such a ready following from philosophers and that it might not have enjoyed such an easily renewed fate. Without this special experience, atomism could only have been conceived as a highly speculative scholarly doctrine in which the idea's initial venture was not justified by any observation.

By contrast, based solely on the existence of dust, atomism has been able to receive, from the very beginning, an intuitive base at once permanent and rich in suggestions. These initial suggestions evidently serve to explain atomism's historical as well as its pedagogical success and, here in particular, philosophy benefits from bringing together pedagogical and historical elements. From this straightforward pedagogical perspective, I will try, in a few pages, to study atomism's simplest image, one that is durable precisely because it is simple and rudimentary. Charles Adam, for example, did not hesitate to see Descartes's younger days as the source of some of his guiding intuitions. As he points out, because Descartes lived in the country, he was able to take note of several curious traits of nature. Among such natural lessons, Charles Adam specifically includes familiarity with

phenomena like will-o'-the-wisp, dust, and whirlwinds.[1] In fact, it should be noted that a *whirlwind* is a rarer occurrence than one might think and that many talk about it who have not had the opportunity to observe it. One must have seen the dust on the road, at the bottom of a ravine, caught up and lifted by a favorable wind to understand what is at once structured and free, light and delicate, in the swirls of a whirlwind. The best-made whirlwinds are the smallest ones. They stay within a wheel path. They can actually rotate around themselves like a humming top. More commonly observed river eddies give us a far cruder image than a whirlwind drawn by dust. Water only gives us a lightly engraved design; dust gives it in full three-dimensional relief.

Whatever one may think of the importance attributed by Charles Adam to these first material images of Cartesianism, there is no doubt that one finds, in what is most often a radically materialist atomistic literature, numerous quotations pertaining to the phenomena of dust. It therefore seems astonishing that Lasswitz does not include in his otherwise detailed index anything that recalls ideas of dust, powder, or pulverization.[2] These concepts certainly deserve to be given priority over amber, mercury, and smoke—which Lasswitz did include.

II

Following these general remarks, let us attempt to appreciate the importance of dust for the teaching of atomism.

We can start by presenting something of a negative proof of the intuitive value of such a phenomenon. All it takes is to imagine how our intuition would be affected by a world of well-defined solids, a world of objects whose individuality would be strongly and clearly related to size, as is the case, for example, for all animated bodies. For greater clarity, let us complete our assumptions by setting up a world where these defined and individualized objects have sizes that extend over a rather limited range, thus containing neither very large nor very small objects. We understand right away that in such a world material division would be seen solely as an *artificial* process. Intuitively speaking, we could shatter, but we could not analyze. Of course, an advanced science might succeed in transferring the principle of individuality elsewhere, agreeing, for example to analyze a solid *geometrically*. But then geometrical analysis and the partition of the real would no longer be synchronous. The former, bearing the mark of ideality, would belong to the world of possibility pure and simple. Nothing real would correspond to it.

Now let us change scientific utopias. Instead of a world of well-defined geometric solids, let us imagine a world of pasty objects, such as, for example, a universe briefly considered by Mach,[3] that is a little too hot, where everything flattens out, where forms inhabited by essential fluidity are nothing more than moments of development. This time, contrary to what happens in our first hypothesis, division is now the law. Every object dissolves, loses its shape, and is endlessly segmented. The ideal pattern is flowing water that divides as easily as it reassembles, thus illuminating a perfect reciprocity of analysis and synthesis. Faced with such a scene, how could we posit the idea of an *indivisible element*? The only way would be to contradict concrete experience and generally observable evidence. And here again our means of separating the real and the possible would be deeply perturbed. Yet all we did was put forth a poor, simple assumption as we constituted our scientific utopia, only to see that assumption modify all that is possible and, like a reagent, precipitate a brand-new reality! In a world of pastes and liquids, it would seem that the possible is, I daresay, more real than immediate reality. For the possible is now everything in the process of becoming, now rendered more clearly by its increased activity. By contrast, reality is nothing more than an ephemeral and accidental form, an individual frame in a film. By underscoring through thought the fluidity of solid bodies, we might have believed that we affected only a material quality, but we realize, in the end, that we have perturbed even the most fundamental categories and forms of our knowledge since we enter into an extraordinary world where time finally dominates space.

So, in a way, we can frame the real world with two hypothetical worlds that are equally easy to imagine: the first where solidity is everything, the second where solidity is nothing. But one can see right away that, in these two utopian worlds, atomism does not encounter the elements of its first teachings since, in one of the hypotheses, division of matter would be an anomaly and, in the other, a rule to be endlessly applied. Realistic atomism is indeed dependent on a direct intuition of material diversity. I have tried to show elsewhere how difficult it is for scientific thought to uncover categories and order within immediate diversity.[4] In some ways this diversity must be seen as irreducible if we want to preserve atomism's full value of explanation. That is why, as we have just seen, atomism immediately loses all meaning when a profound, hypothetical cause of uniformity is slipped into the real. The concept of dust, halfway between that of a solid and a liquid, will, by contrast, furnish a sufficiently mixed proof on which to base atomism.

Of course, as I indicated earlier, this is but a negative argument, one that tends to underscore atomistic philosophy's dependence on the very general empirical conditions in which thought is developed. I must now begin a more positive examination and take things as they are, not only in their multiple forms but also in their frequent deformations.

III

The thesis that I will defend, at once general and complex, goes against Bergsonian theory in that it sets out to complete a proposition that, in its very essence, should not require completion.[5] Indeed, Bergson undertook to assimilate our fundamental habits of thought to our everyday experience of solids. According to him, everything that is framed, categorical, and conceptual in human intelligence stems from the geometric aspects of a world of solids. Our experience of solids leads, in a way, to solidifying our actions. Objectivity as stability is thus related to the solidity of objects. Only what is solid is thought to hold a sufficient number of features strongly enough to represent and maintain the "dotted line" that outlines our possible action. In the face of the simple sketch of our actions thus geometrized through our experience of solidity, all other natural phenomena come across as irrational.

Bergson has surely uncovered in this instance a dominant feature of understanding. In particular, everything that is exchanged socially is expressed in the language of solidity. Similarly, a substantive noun is, in effect, defined from the outside. It can be placed in any sentence the way a solid is placed in any location. In its logical form, language thus corresponds to a geometry of the well-defined solid. But here is where Bergson's thesis needs to be extended. If the initial orientation of intellectual and verbal organization really means the immediate utilization of objects of experience, how do we delete equally characteristic elements from that everyday experience? How do we overlook flowing water, silent oil, sticky honey, paste, mud, clay, powder, and dust? To be sure, all these things find their way back to solidity, but they also contradict certain essential characteristics of solids. Let us not object that solidity is the rule and that liquid or dust are exceptions. For it is quite remarkable that, as principles of explanation, clear and flagrant exceptions carry the same quotient of conviction as do general characteristics—a strange dialectic this, one that thrives on oppositions yet rejects from the bases of its explanation only those elements that are mixed and mingled! Even from a scientific perspective, are the most frequent themes of an explanation not the perfect,

undeformed solid and the perfect liquid without viscosity, in other words, two features that are frankly exceptional? One has to arrive at a very advanced physics to find any appeal in the study of mesomorphic states.[6] But from a psychological point of view—the only one that interests me at the moment—these studies of intermediate states are analytical; they are expressed with the help of supposedly simple primary states. At the same time, states taken to be primary—solids, liquids, paste, or dust—do not raise questions; they provide the direct *answers* of intuition. They are *elements of naïve explanation*. As a result, it is all of nature that teaches us, and understanding enters through all our senses. Thus, we must speak of a kinetic intelligence alongside the geometric intelligence given primacy by Bergson. We must even add a materialist intelligence. Ultimately, we must recognize that our language is, if not by its nouns at least by its verbs, as tactile as it is visual. Henceforth a more objective intuition of matter will lead to what is, from many points of view, a broader Bergsonism.

In my view, a deformation, even when visual, is not understood as a mere loss of forms, for as soon as we consider how our actions are accomplished, we realize that the deformation we impose on things always means actively acquired information. And so it is a question of taking shape, often with great difficulty, rather than losing shape. Thus, we come to experience deformation as dynamism. For example, the idea of penetrability acquired in the potter's arduous manual experience proves to be fundamental.

Henceforth an impenetrable solid is seen as an outright exception. The outline of its shape corresponds to nothing more than our idleness, a prospect of laziness, and a philosophy of the immediate. If we wish to relate Homo sapiens to Homo faber, we must consider the latter in all manner of actions. Homo faber arranges and kneads; such an individual welds and grinds. For that person certain bodies are juxtaposed, others are mixed together, and still others are dispersed in dust and smoke. Solids demonstrate the great lesson of form and assembly. From liquids comes the equally fruitful and clear lesson of change and mixture. From the phenomena of dust, powder, and smoke, Homo faber learns to meditate upon the delicate structure and the mysterious power of the infinitely small; along this path lies the knowledge of the impalpable and the invisible.

And so the primacy of explanation via solids is compromised at the very core of popular knowledge, in the domain of initial intuitions. Besides, even if we were to assume that the problem of the intuitive origin of knowledge remained unre-

solved, we would at least have to admit that the characteristic of absolute solidity attributed to bodies is *a characteristic to be rectified*, since the best-known phenomena soon display a departure from the quality of perfect solidity. In reality, our thinking is more in line with the deformation of a body than with the geometric relation between many bodies. Thus, Bergson's thesis designates only a point of departure. It is unable to account for the complete evolution of objective thought.

In short, whether through utopian assumptions, or through glimpses that describe matter in the actuality of its multiple states, I believe I have restored to my intuition an unfocused and free character brought about by several sensory sources. It will now be easier to sever the link that is always too narrowly established between principles of atomism and geometric intuitions derived from observing solids. Following this polemical preparation, let me now move to a truly positive examination of my thesis. Let me attempt to demonstrate that the intuition of phenomena of dust truly undergirds naïve atomism.

IV

We should, first of all, recognize as fact what in fact exists. Now the experience we have of powder and dust is far from negligible. This experience is so singular and striking that we can speak of a *powdery* state exactly in the same way that we speak of solid, liquid, gaseous, and pasty states. In reality, in modern science this powdery state always poses problems of its own. For example, we see a more energetic chemical action in powders. This chemical potency of powder derives from a kind of surfacing. Zones of transition and contact will give way to special phenomena. Catalytic actions appear that would have no impact coming from a material taken as a mass. Thus, Auguste Lumière points out that exchanges and reactions that take place in the tissues of a human adult extend to a surface of two million square meters: "However minute the affinities may be of substances coming into contact on the periphery of granules, we can conceive that the sum of all these infinitesimal elementary reactions can become considerable when occurring over such large surfaces."[7] We might thus say that, through granulation, *surface* takes on an authentic substantial reality. It ceases to be geometric to become truly chemical.

Even from a coarser and more mechanical perspective, powders work in a special way; their drift and flow lead us to study carefully the shape of their containers or the partitions along which they must slide. But it might be objected that this too

is a new and delicate technique. So let us locate the freshest intuition possible.

Let us first consider a child's amused attention before an hourglass. Let us contemplate, along with that child, a complex of exceptions! Powder is solid, yet it flows; it falls noiselessly. Overall, surfaces are at once mobile and stable. Mounds will grow; craters will form in which one can see uncaused movement begin. If now we try to reconstruct the overall phenomenon starting from the movement of separate particles, we are amazed to see the regularity and the measure produced by a truly insignificant and lawless body. A paradoxical water clock where solidity displays its fluidity, the hourglass surely provides the first measurement of brief time. It is the glib symbol of a useless duration.

Powder, talcum, flour, ashes—all similarly hold the attention of alchemists and chemists in every period of the development of prescientific thought. It seems that a crushed body, in losing some of its individuality, simultaneously acquires an unexplained character of mystery. Powder arouses the suspicion of poison, it is an essence that, depending on the dose, may bring remedy or death. It is a sorcerer's material.

At times, it is due to the *uniformity* of dust that we think we can attribute a broad role to matter. Thus, a late-eighteenth-century author will associate dust with germinating soil. Air, says Deluc, works on terrestrial matter "ceaselessly and in a thousand ways. By simply rubbing all bodies of matter it removes such tiny particles that they are unrecognizable. The dust in our dwellings may well be an example. Whatever the nature of its source material, it is a grayish powder that seems to be everywhere the same. The formation of germinating soil is probably related to that. All surfaces of the earth, from the hardest rocks, the most arid sands and gravels, even metals, suffer the gnawing action of air; and their particles, reduced, decomposed, and reconstituted in myriad ways, are likely the main source of germination."[8] And so this uniformity, advanced on the basis of our inability to discern specific characteristics, is enough to explain that dust properly encompasses the most varied vegetative needs. In other words, vegetative comparison is no better able to discern differences between grains of dust than is human sensory activity. It would seem that, as solids diminish in scale, they are substantially simplified and thus become *elements* suited to the most diverse constructions. These particles, adds Deluc, "extracted or fixed by procedures that bring them closer to their initial elements and, in our eyes, cause them to take on the same appearance . . . are thus suited to spread in the seeds of plants, to expand

their tissues, to take on all the properties that characterize each species, and to maintain them as long as the plant exists. After the plants are destroyed, these same particles take on the general character of germinating soil, that is to say a ready-made reserve for *germination*."[9] Let us also note, in passing, the paradoxical idea that dust, the final result of all destruction, is easily posited as indestructible. The attribution of eternity to the atom in certain philosophical systems may have no other origin.

Thus, at the basis of our intuition of powder and dust are very curious judgments of value, since substances in this form are sometimes considered trash and, in others, worthy matter. We are amazed, in fact, when going from one judgment to the other. For example, who has not been struck to learn about new forensic tests? It takes all the talent of a Locard[10] to convince us that a criminal investigation can be explained through microscopic analysis. We had been led, through a pragmatism that was as crude as it was negative, to tacitly assume that substances lose their individuality when reduced to dust. We are therefore quite surprised to learn about the material individuality of the infinitely small. Moreover, thanks to the effortless dialectic of amazement, we are soon led to be amazed at our surprise. Thus, we don't hesitate to exaggerate newly recovered individuality and to postulate a set of qualities for material particles that are more characteristic than aspects of matter in its massive form. And so it is, as I will show, that naïve atomism assigns to elements qualities that are apparently not related to regular solids.

In addition, we might understand the influence of pejorative judgments often associated with dust by recalling certain related conditions such as *wood-rot* and *rust* that keep intuition in the prescientific stages. For example, rot, in and of itself, serves as an explanation, and the seventeenth century does not hesitate to believe in the action of a special worm that attacks metallic substances—dust from rust is considered the same as dust from wood rot. A *table of presence* might bring the two phenomena together and provide a Baconian explanation adequate for knowledge limited to relating two intuitions.

Along these lines, going on now to generalizations, we will understand that one of the great arguments of atomism, endlessly repeated by the various schools, has to do with wearing down the hardest of bodies. The temple's bronze doors hollow out under the faint touch of the hands of the faithful. The atom is now a worn solid. After a long success of creative effort, everything returns to the chaos of disassociated and mixed atoms. This theme of the general wear and tear of things,

of the destruction of integrated forms, and of the amorphous mixture of diverse substances is the basis for numerous materialist philosophies that can thus adapt their pessimism to a sort of aesthetic decline of the Cosmos.

The question can also be approached from another angle. If dust and powder are valued for their direct explanation, we will be led to value the pulverization of solid bodies as a truly fundamental process. We will not hesitate, at that point, to explain complicated physical phenomena in terms of the idea of pulverization, which will play the role of a *simple idea*. That is how Hélène Metzger quite rightly characterizes the psychology of a seventeenth-century chemist: "Like all dabblers in pharmacy (Arnaud, 1656) crushed solid bodies in a mortar. He believed that all chemical operations have some relationship to that one, that they may be finer or cruder, but that, ultimately, the chemist's entire art boils down to the mechanics of pulverization."[11] Pulverization is the clear and primitive idea, to which all chemical reactions must be brought back: "What is calcination? Seventeenth-century chemists reply that it is a process which consists in pulverizing different bodies by fire, either by action of the flame's actual fire, or by action of the potential fire found in acids and other corrosive materials."[12] In the *Encyclopedia* (under "pulverization")[13] one can also read that "calcination, either by fire or, by the assistance of niter and of sublimation into odors, is still, as to its effects, a type of pulverization." We can thus readily see that, for several centuries, the pulverization of substances was not merely a procedural means, but indeed had the importance, in the mind of the chemists, of a fundamental intellectual framework.

V

Up to now, we have observed powder and dust in their rather diminished or at least static and inert aspect. But it is when we come to fine, light dust stirring and shimmering in a ray of sunlight that we really grasp the master intuition of naïve atomism. This is a spectacle we often contemplate in our reveries. It is capable of liberating our thoughts from the everyday laws that regulate active and utilitarian experience. In a way, it contradicts such willful experience, leading us to sever the link established by Bergsonian philosophy between our actions and concepts. Reflections born of this spectacle immediately have a speculative tone. They readily take on the function of learned reflection since they explain the general by the singular and the special, a method used more often than one might think at first glance.

The entire set of departures from usual laws, when manifested in the aerial play of dust, is precisely what makes its intuition so appropriate. The speck of dust, in particular, departs from the general law of gravity. For a truly primal intuition, need it be noted, it floats in a *void*; it follows its fancy. Of course, it responds to puffs, but with what freedom! It illustrates the *clinamen*.

Through a profusion of colors and iridescence, the speck of dust dancing in the light also illustrates the multiple properties of an isolated object. Upon looking at it carefully we think we understand that the element, simple in its substance, can be composite in its attributes and modes.

But the principal explanatory value derived from the speck of dust, its true metaphysical meaning, is surely that it brings about a synthesis of opposites. It is intangible and yet visible. A strange object that affects but one sense, that presents itself as a kind of natural abstraction, an objective abstraction!

But let us go further—in this experience what becomes visible is the invisible. In fact, as long as a reflected and diffuse light fills the room with a uniform clarity, the room is empty, the dust is invisible. Let a sharp, straight ray appear and immediately this ray of light reveals an unknown world. This is really the first experience of atomism; this is where atomistic metaphysics touches upon the basic physics of the atom; this is where speculative thought finds support in an immediate intuition. From now on, in fact, we can recognize our right to postulate matter beyond sensation since, in a way, experience has shown us the invisible. So we postulate the atom of matter beyond the experience of the senses. We are ready to speak of the atom of smell, of sound, and of light since we have just seen, in an auspicious and exceptional experience, the intangible atom of *touch*.

Such nimble and free matter might obey the impulses of the soul; it might be spirit itself. As Léon Robin recalls: "Aristotle, who does not name the Pythagoreans when he speaks of soul-harmony, expressly attributes only two opinions to them: according to the one, whose relationship with atomism he does not fail to point out, the soul is made up of dust particles floating in the air, highlighted by a ray of sun, and perpetually on the move, even in the calmest moments, while according to the other, the soul is seen as the root of their movement."[14] In both cases, therefore, there is a correspondence between the elements of the soul and the elements of matter. The atoms of the soul, adds Émile Bréhier in interpreting the same intuition,[15] are in equal number to those of the body and are juxtaposed

to them by alternating one-on-one with them; they are constantly renewed by respiration. How can we not then consider that for early thought, the spirit of life takes shape in a puff of breath; how can we not relate the intuition of the mind to the observation of light animated by atoms that fill an infinite void?

From an animistic perspective a sort of *passage to the limit*[16] can be discerned that allows us to transcend matter. But in a more general and more material way, that is precisely where the epistemological usefulness of the observation of dust resides—it prepares and legitimizes a passage to the limit. That is the way Descartes makes use of this intuition in his book on meteors. In speaking of vapors and exhalations, he points out that specks of dust are much larger and heavier than the small portions that constitute vapors; nevertheless, he adds, "that does not keep them from pursuing their course toward the sky."[17] Here one can really perceive the powerful example of phenomena viewed in a ray of light. What dust can do, how could the atom or the fine matter of exhalation not be able to do? If dust manages to escape gravity, how could the atom not find its independence? If the experience of dust is still crude, all that is needed is to pass to the limit and we will attain, through thought, an atomic physics that will give the impression of being rational while still maintaining an experiential basis. Here then, in short, is the progression of arguments that carries forth the initial intuition and that establishes philosophical atomism as a doctrine at once rational and empirical.

VI

In connection with the intuition of dust, one should also study the intuition of the void, for it is not difficult to show that it also is a quite positive one. In fact, upon reading the Greek philosophers, we become convinced that the entire polemic over the void amounts to either aiding or combating that intuition. But in any case, when we first encounter this basic intuition, the void poses problems from a metaphysical perspective by the very fact that it raises no problem from a psychological point of view. Such a polemical outlook is well suited to demonstrate that the void and dust are truly immediate and important facts of experience.

This essentially derivative aspect of the metaphysical problem of the void is so clear that the problem is sometimes stated in a totally metaphorical, even unwritten way. We read in Aristotle, for example, that "if we are to believe the Pythagoreans, the void is originally found in numbers, for the void is what gives them their particular and abstract nature."[18]

All these arguments against the void are also interesting to my way of thinking in that they underscore the power of a first intuition carried into the most varied domains. Thus, for Plato and Aristotle, it is a question of combating the idea of a void that would be an instrument of general annihilation and that would bring to all substance the contagion of nothingness. They argue, in fact, that in the void, bodies would lose their specific properties. For example, with respect to motion, the void would erase individual dynamic properties. Thus, Aristotle concludes that "all bodies in the void would have the same velocity, and that is not admissible"[19] since the void would, in fact, take away from motion the fundamental Aristotelian characteristic of velocity. Besides, in a more general way, the properties of bodies in Aristotelian physics are, as we know, entirely relative to their environment. A given property is more than *localized*, it is truly *local*. The attributes of a substance must be forced, in a way, to remain in the natural venue of that substance. Otherwise, the substance could not really retain its attributes, which would undergo a sort of metaphysical evaporation. In the final analysis, Aristotelian dialectic is led to replace the intuitive void by a space that, if not real, is at least necessary to assure that objects retain their real qualities. It is acceptable for the space to be empty of substance, but it must maintain a relationship to the substances it contains. It must *realize* the minimum necessary for the principle of sufficient reason to be applied. This point of view is very clearly summarized by Léon Robin: "With the venue deprived of all natural properties of location, what reason would there be, in fact, for a body to move in any particular direction? How to explain, as well, the accelerated motion that, to the contrary, a body displays when in the vicinity of its *natural venue*?"[20] But really, in implementing rational necessities, all we did was fill space with reasoning, and we still have to make the characteristics produced by the immediate intuition of the void reappear. Thus, Barthélemy-Saint-Hilaire underscores the dialectical character of properties attributed to space and bodies by Aristotle. Matter that fills space, he says, "is not such that it can oppose the least obstacle to motion, and motion occurs with such a constant and perfect regularity that, evidently, nothing troubles or hampers it."[21] But then, who does not see that positing metaphysical fullness amounts to attributing to it all the characteristics of the intuitive void? Fullness even has as its only function to maintain the properties of things, to bind attributes onto atoms in some way. The initial intuition has been enriched rather than impoverished; it remains whole. Once again, metaphysics has recovered what it had willingly lost. After a long detour, we must come to the conclusion that space is not a physical environment like any other, that it neither impedes nor produces motion, that it leaves undetermined all the reasons it contains for forecasting phenomena. Meta-

physical plenty remains a physical void.

If the reader hesitates to follow me in this affirmation of the persistent character of the first intuition of the void, I have in reserve an argument that will otherwise answer an objection that is quite natural.

Surely, no one has failed to object that, in fact, the experience of the *void* for the ancients as well as for common knowledge is obviously erroneous since all the early physical experiments are carried out in air, with an almost total ignorance of phenomena peculiar to the gaseous state. We should then concede that the direct intuition of the void corresponds in reality to the experience of a physical state that, in itself, is well determined although poorly known. But an error of thought or expression has nothing to do with the truth of an intuition. What must be called the tangible perception of the void is closely linked to a quite positive observation.

Let us try to specify the experimental characteristics of this intuition. Air for the ancients was always the wind. In ordinary experience, if air is immobile, it somehow loses its existence. Wind is always a power of coordination. That is why the disorderly movements of dust in a ray of sun are not attributed to the wind. Here again, these movements represent an exceptional state, and, through a sort of dialectic, they display an ambient *void* as still another exceptional state. Immobile air is decidedly the intuitive void. It has no action, and it is the indicator of nothing, the evident cause of nothing. Accordingly, by taking the experience of aerial environment such as it appears initially in its general and simple aspect, it has to be recognized that this experience is well suited to providing a proper substitute for the void. In the final analysis it cannot be argued that the scientific error of an intuition destroys the power and clarity of that intuition.

This immediate and enduring clarity explains the difficulty brought on by the first scientific experiments following the invention of the air pump. By following these experiments over the course of the seventeenth and eighteenth centuries, we perceive the transition of an absolute and clear idea to a relative and confusing one. This transition was psychologically difficult and the idea of a *relative* void, so familiar to us now, was long a difficult idea to analyze.

Initially this relative void was taken to be essentially artificial. For a very long time, it was called Boyle's void, after the English physicist who multiplied the

experiments. It was a technical state whose properties seemed as new as radium must have seemed at the beginning of the twentieth century. Considered to be a paradoxical state, it drew astonishing, extraordinary, and legendary observations. To give just one characteristic example, let us cite the claim of distinguishing between properties of the void when air is removed from a cubic vial or from a spherical one. With the action of the air pump, the first would shatter, the second would resist.[22]

Finally, more learned intuitions, based on the image of rarefaction developed through statistical analysis, very slowly began to help follow experiments in their particulars. These intuitions have profoundly permeated the culture of our time. We must forget them in order to appreciate the play of detail from the earliest intuitions.

To sum up, atomism is, first of all, a visually inspired doctrine. To ambient air corresponds a void of optic sensation. The material characteristics of gasses can only be understood through a scientific experiment, with technical means that are difficult to apply. Optical characteristics thus conserve a sort of natural explanatory value. Dust and void apprehended in the same glance truly illustrate the first lesson of atomism.

NOTES

1. See Descartes, *Oeuvres complètes*, ed. Adam-Tannery, vol. 12 [(Paris: Léopold Cerf, 1903)] *Vie de Descartes*, 17, note. [Hereafter cited as *Oeuvres complètes*.]

2. [Lasswitz, *Atomistik und Kriticismus.*]

3. [Ernst Mach, 1838–1916, Austrian physicist and philosopher after whom is named the number that identifies the ratio of a given speed to sound.]

4. See [Gaston Bachelard,] *Le pluralisme cohérent de la chimie moderne* (Paris: Vrin, 1932). [Hereafter cited as *Le pluralisme cohérent*. For further discussion, see also Roch C. Smith, *Gaston Bachelard: Philosopher of Science and Imagination* (Albany: State University of New York Press, 2016), 19–21. Hereafter cited as *Philosopher of Science and Imagination*.]

5. [Bachelard frequently challenges the ideas of French philosopher Henri Bergson (1859–1941). See Jean-François Perraudin, "Bachelard's 'Non-Bergsonism,'" in *Adventures in Phenomenology: Gaston Bachelard*, ed. Eileen Rizo-Patron, Edward S. Casey, and Jason Wirth (Albany: State University of New York Press, 2017), 29–47.]

6. [A mesomorphic state ("état mésomorphe") is defined as a state of matter whose symmetry is intermediate between a solid and a liquid and that is found especially in certain elongated organic molecules (liquid crystal) "état de la matière dont la symétrie est intermédiaire entre celle d'un solide et celle d'un liquide et qui se rencontre surtout avec certaines molécules organiques allongées (cristal liquide)." http://www.larousse. fr/dictionnaires/français.]

7. A[uguste] Lumière, *Théorie colloidale de la biologie et de la pathologie* (Paris: Étienne Chiron, 1922), 69.

8. J[ean]-A[ndré] Deluc, *Lettres physiques et morales sur l'histoire de la terre et de l'homme*, vol. 2 (Paris: V. Duchesne, 1780), 29.

9. Ibid., 30;

10. [Dr. Edmond Locard, Bachelard's contemporary, established the basic principle of forensic science that "every contact leaves a trace," known as Locard's exchange principle. https://sites. google.com/site/apchemprojectforensicchemistry/experts-in- the-field.]

11. H[élène] Metzger, *Les doctrine schimiques en France du début du XVIIe à la fin du XVIIIe siècle* (Paris: P[resses] U[niversitaires de] F[rance], 1923), 61. [The "dabbler in pharmacy" mentioned by Metzger is E. R. Arnaud, a Doctor of Medicine who published an *Introduction à la chymie ou à la vraye physique* in 1656, where he sought to improve medicine by "having the physician enter the pharmacist's laboratory to discover . . . that the sciences, far from combatting each other, must strive for mutual enlightenment" ("faire pénétrer le médecin dans le laboratoire du pharmacien, lui montrer . . . que les sciences, loin de se combattre, doivent essayer de s'éclairer mutuel- lement") (Metzger, 59–60). Hereafter cited as *Les doctrines chimiques en France*.]

12. Ibid., 372.

13. [The reference here is to the famed work of the French Enlightenment, the eighteenth century *Encyclopédie*, edited by Denis Diderot and Jean le Rond d'Alembert.]

14. L[éon] Robin, *La pensée grecque et les origines de l'esprit scientifique* (Paris: Albin Michel, 1923), 82. See also 145. [Hereafter cited as *La pensée grecque*.]

15. Bréhier, *Histoire de la philosophie*, 1:80. Bréhier refers to *Lucrèce*, I, 370.

16. [With this "sort of passage to the limit" Bachelard seems to be anticipating the calculation to the limit that will be used in calculus to measure the infinitesimal.]

17. Descartes, *Oeuvres complètes*, 6: 240.

18. Aristotle, *Physique*, bk.4, chap. 8, §9, French trans. B[arthélemy]-Saint-Hilaire, 191; [Paris: Vrin, French trans. A. Stevens, 2012 (Editor's note)]. [For English trans., see Aristotle, *Physics*, bk. 4, chap. 6 (213b, 23–27).]

19. Ibid.,bk. 4, chap. 9, §18. [English trans., bk.4, chap.8 (216a,20).]

20. Robin, *Lapensée grecque*, 337. [The 2015 printing of *Les intuitions atomistiques*, on which this translation is based, mistakenly attributes this citation to Aristotle. The quotation, as indicated in the original 1933 edition, and as noted here, is from Robin.]

21. B[arthélemy]-Saint-Hilaire, preface to Aristotle's *Physique*, xiv.

22. This observation continues to be related in Diderot and d'Alembert's *Ency- clopédie*, s.v. "Vuide," last column.