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SCIENCE, NATURE, QUALITY*

The questioning of Western civilization is today a commonplace exercise, and the condemnation of science constitutes a necessary chapter. But is this condemnation of science or of technology, or of the uses that modern society makes of one or the other? We do not want to examine here the value or the means of a political control of technology nor do we want to distinguish between "pure" science and its blameworthy applications. The ties are too tight and historically too evident between Western civilization and the development of science. It is science itself which is in question, and one more commonly blames it for ignoring the quality of things and for not recognizing anything but the measurable. Around this central criticism are rather confusedly expressed secondary themes, ranging from "the quality of life" up to the ineffable modes of special communication.

But what value has the quality-quantity antithesis on which this criticism is based? Is it particularly true that the history of Western science is nothing more than a progressive elimination of the qualitative by the quantitative? Only history can answer, but it risks showing that the problem is not such a simple one, and that a well-based criticism of scientific development must take other notions into account.

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The classical archetype of qualitative science is Aristotle's physics, which ruled practically unchallenged in Western thought up until the 17th century. It suffices to recall that Aristotle defined as "principles of sensitive bodies" four fundamental qualities: hot, cold, moist, dry. They are fundamental because "all other differences are reduced to the four first ones, but they themselves are not further reducible to a smaller number."[1] The difference, that is to say the identifiable, is based on quality. The "elements," simple bodies or bodies that seem simple, are defined by a pair of qualities: fire is hot and dry, air is hot and moist water is cold and moist, earth cold and dry.[2] All "sensitive bodies," or "mixed bodies," are composed of these elements, and their properties, including the derivative or secondary qualities, are the result of the play and the proportions of the elementary qualities.

But these qualities are qualities of a *substance*, defined by matter, form, and privation.[3] Without substance nothing is qualifiable, nor even quantifiable: "if all is quality or if all is quantity, whether the substance exists or not is absurd, if one must call the impossible absurd. In fact, nothing else is separable because substance characterizes everything."[4] In listing qualities or quantities, we are only speaking of the substance: "quantity, quality, relation, time and place are produced, given a certain subject, because only substance does not derive from any other thing as subject, and all the rest derives from substance."[5] Substance defined by matter and form is the object of knowledge: "Science must know not matter alone, but form and matter."[6]

The form-quality relationship is not, however, always very clear, especially when it is a question of elements, constituted by a primary matter inaccessible to the senses, and by form which is only defined by a pair of qualities. It is understandable that Averroes was able to propose attributing the form of a being to the sum of its qualities. But form is the basis of the rationalization of the real and must assure the continuity of rationality.

[1] *De la génération et de la corruption*, II, 2.
[2] *Ibid.*, II, 3.
[3] *Physique*, I, 7.
[4] *Ibid.*, I, 2.
[5] *Ibid.*, I, 7.
[6] *Ibid.*, II, 2.

If there is contamination of form and quality it occurs much more from the former to the latter than vice versa. The antithetical qualities present in a mixture are not cancelled, unless they do not both diminish. Hot and cold do not make tepid: one *masks* the other which will reappear intact when the mixture is reduced into its constituent elements.

Without doubt these primary qualities are taken from experience. Like the secondary qualities they express a relationship of things to us. But to be able to rationalize perceptible reality, they express a relation to a universal subject that is not subjective, and is seemingly absent. These are objective qualities, that is to say a creation of reason more than of experience, and reason cannot verify them, much less measure them. Quality has therefore a substantial nature, evident in the Aristotelian concept of movement, a qualitative change of substance of which motion is only one aspect.

The qualitative physics of Aristotle and the quantitative physics of modern science can only therefore be opposed to each other by artificial means: they demonstrate different systems of thought and do not mean the same thing. Aristotle's physics attempts to be a science of substance and of its modifications, a science of the nature of things, whether variable or stable. The study of qualities is only one method of understanding variability and stability; that change is change of something that actually exists cannot be overlooked, and it serves as support to the rationality of the universe.

The passage from the rationale of substances to the rationale of classical science will be long and difficult. The uncertain and complex universe testifies to this change which is exemplified in the thought of the Aristotelians of the 14th century, who at Oxford and Paris undertook to reflect on motion. In order to represent uniformly accelerated motion arithmetically or geometrically, it is not enough to render an Aristotelian quality into quantitative terms. All the resources of a system must be used to introduce a category of another order into it, an abstract concept, independent of all substance, which is the concept of speed and its variations.[7] One can consider speed as a quality,

[7] An elucidation of the subject and a bibliography can be found in M. Clavelin, *La Philosophie Naturelle de Galilée* (Paris, 1968), ch. II.

but it is a quality of an abstract being, movement, and no longer of a substance. Here we arrive at the heart of the problem: the appearance of quantity does not presuppose the disappearance of quality but the disappearance of substance, that is to say, of the nature of things.

To understand this change, we must first examine not the history of science but the history of ways of thinking, and before that, economic and social history. As is commonly known, the development of commercial activities and the ever more important position occupied by merchants in the city is what imposed and generalized the ever more precise measurement of time and space, like the measurement of commodities and the arithmetic techniques of accounting. Undoubtedly, the introduction of measurement and calculus into science was encouraged by the Pythagorean and Platonic tradition. The mysticism of numbers is a far cry from mathematical physics, and one could ask if in the 16th century geometry or arithmetic are still truly sciences of measurement and of quantity or if they are in their own fashion sciences of properties, that is, of qualities, figures, and numbers.

If it is true that measurement spreads in science at the end of the 16th century and at the beginning of the 17th century, many ambiguities nevertheless exist. Galilean physics owes less perhaps to rigorous measurement of experimental data than to the basic conviction that "nature is written in mathematical language." Measurement is still used, although the researcher often does not possess the conceptual equipment capable of guiding it, which amounts to saying that people measure anything. Sanctorious or Van Helmont testify to this. To render in quantitative terms is not science, but, what is more important, the gateway to a new rationale.

Now this new rationale, which blossomed while discovering itself already in the 17th century, does not reject qualities: it is content with creating new ones. The necessary debate on secondary qualities both masks and reveals the uncertainty concerning the primary qualities. The only agreement is by refusal: to the Galileo of *Il Saggiatore*, the Descartes of *Discourse on Method* replies: "I expressly presupposed that there would not be in it (matter) any of these forms or qualities which were argued about in the Schools." This shows a negligent and significant confusion between form and quality: but what is relevant is that Descartes

wants us to speak only of matter. The real object of the Cartesian refusal is not so much quality as its support, substance. The essence of things will be nothing more than matter, that is to say, extension.

This is the first aspect, however. Extension is a quality which is measurable, and movement is no less measurable. It is well-known, however, that Cartesian rationalism only uses very moderately the measurement and calculus that it authorizes, as witnessed by the last two parts of the *Principia.* The fact is that Cartesian physics is primarily geometry and in it movement remains external to matter. In brief, matter does not have enough qualities for measurement to rule in its physics; for it is quality which can be rendered in quantitative terms. Kepler understood this better than Descartes when he wrote: "Everywhere that there are qualities, there are also quantities."[8] Though insufficient, the Cartesian intervention had been nevertheless decisive: despite the efforts of Leibnitz the notion of substance will no longer be understood in the 18th century.

At the end of a long discussion, Locke had made up a list of the primary qualities, those which are really part of things: solidity, extension, shape, number, and motion or rest. These were passive qualities of matter, a list almost immediately outmoded thanks to the work of Newton. To add to the prestige of modern science, Newton introduced a property, an active quality of matter: gravitation. That caused a scandal, and the best minds of Europe rejected the new motion. Presented without an identifiable cause, this quality manifested itself as or by a force, revealed only by its phenomena. That its means of action, that is its law, could be described by mathematical formulae, was not considered on the whole as determining an advantage. It took time for Newtonian science to make its own way and to make qualities that can be rendered in quantitative terms the basis of modern physics.

What was at first adopted after the initial hesitation was precisely the qualitative aspect of gravitation, rather than the mathematical aspect of the law. The concept of attraction was introduced by Newton himself, first in chemistry, then in biology.

[8] Quoted by Burtt, *The Metaphysical Foundations of Modern Physical Science*, London, 1967, p. 57. Kepler adds: "The opposite is not always true." Is this the case as regards *quot?*

Chemists and biologists are agreed in maintaining that the rendering into quantitative terms and mathematical formulation, which are possible in celestial mechanics, are no longer possible in the sciences of matter or of living things. Of the concept of gravitation there only remains the notion of quality and of force, which at the end of the 18th century was sometimes carried to extremes.

At first Newton had been reproached with having resuscitated the all too famous "hidden qualities," and not without reason; Newton had vigorously defended himself on this count, and rightly so. The fact is that hidden qualities, known by their effect and unidentifiable in their causes, had received two contradictory explanations. Being completely inexplicable by means of its primary qualities, the hidden quality was *virtus totius substantiae.* According to the accepted idea of substance, and of form on which it was based, one can infer a secret virtue of things in themselves, or a gift of God in this same thing. Newton was personally more inclined toward the second hypothesis but he was not followed unanimously. In other words, the 18th century continued the scholastic debate: was gravitation an "essential" quality or only a "general" quality of matter? Taking it *stricto sensu,* the word "essential" was sufficient to prove the origin of the debate. Materialism, holding on to this "essential quality," replaces Aristotelian substantialism, without destroying it, and rejects an unsupported quality. This is a fragile position, however, and subject to a Leibnitzian criticism that has become classic: since matter can be divided to infinity, it cannot be a substance. On the contrary, by admitting that quality is a gift of God, passively received by indifferent matter, Newton tended to detach it from its support; but he measured the effects of it and put them in equations. By doing this he succeeded where both Descartes and the materialists failed: he created a mathematical rationale at the level of phenomena, i.e., of quality considered independently of its support, be it substance or matter. In other words he creates classical science, and it matters little here that his motives derived mainly from theology.

It is thus because it is divested of matter that quality becomes fully the object of measurement, that is to say, of science. Barring classical science, that which poses the question *quantum*? much more than the question *quot*?, which rests on a continuistic

intuition of space, of time and of variation, and formulates its laws in continuous functions. If quality is the real object of knowledge, all hypotheses on the nature of matter are allowed. A Newtonian of the 18th century, John Turbeville Needham, will be the first, or one of the first, to criticize the Cartesian notion of matter, and will maintain that in reality matter does not exist, being only an illusion aroused in us by the antithetic action of two primitive forces of action and reaction.[9] Without going that far, classical physics was able to develop without really taking sides on the nature of matter, and it is not on that issue that it has encountered its greatest difficulties of entering into the study of wave phenomenon or the theory of fields.

The general evolution of science after Aristotle up to the 19th century was not therefore a progressive history of quantity over quality but the success of quality which can be rendered in quantitative terms at the expense of ineffable essence. This evaluation predicated a deep alteration of the notion of quality itself. Instead of being the accident of a substance, *esse secundum quid*, as St. Thomas Aquinas said, quality is no more than a relationship between two beings whose individual essence needs no longer be defined because it is in the end indifferent.

The scientific revolution of the 20th century has done nothing more than accentuate this tendency. Modern science studies the state and properties of a system where matter and energy are unceasingly transformed into each other. The object of research is no longer a thing in itself which would exist together with its qualities external to the observer. "The thing in itself," writes Heisenberg, "is in the end a mathematical structure for the atomic physicist, if however he uses its concepts."[10] Without an object there are no more "objective" qualities: "These qualities are nothing less than the result obtained by the execution of operations," says H. Dingler.[11]

At this point where quality disappears in a relation, where the physical object is no more than a mathematical formula, it is nature that disappears, not by chance or by some ill will but

[9] *Nouvelles observations microscopiques*, Paris, 1750, pp. 267-8, 331 and 454-8. According to Needham, primary qualities are just as subjective as secondary qualities.

[10] *La Nature dans la Physique contemporaine*, Paris, 1962, p. 34.

[11] In *Nature*, vol. 168, 1951, p. 630.

as a result of the normal functioning of scientific rationality. Not content with being "master and possessor of nature" as Descartes wanted him, man denies it, as he had denied God, because he had nothing more to say about it. Perhaps it was necessary first to deny God in order to be able to deny nature, that is, as Herbert Marcuse[12] explains it, to be able to manipulate it or destroy it at one's convenience.

Nobody today is unaware of the fact that this destruction is a suicidal gesture. But even before it attained the proportions that all know, man had already annihilated himself by taking himself as an object of scientific research. The notion of "human nature" very logically disappeared upon contact with a rationality which could only know relationships. Michel Foucault caused a scandal in writing in an entirely different perspective, "Man is an invention whose recent date, and near end, the archeology of our thought easily demonstrates."[13] The question has been taken up again today with insistence: "It is in a dramatic, uncertain, and aleatory fashion that one poses today the problem of the nature of man," writes Edgar Morin,[14] and Georges Balandier: "It becomes more and more difficult to neglect that which depends on the nature of man and on the fact of the presence of man in nature."[15] But what is the nature of man?

Substance, quality, relation: three states of the scientific rationale that have eliminated being from things and from man. Antiscience only offers myth. Can one invent a rationality that does not destroy its object?

[12] *L'homme unidimensionnel*, Paris, 1968, ch. 6, pp. 171-180. According to H. Marcuse, the exploitation of man by man and of nature by man are but one and the same phenomenon, characterized by scientific and technological reasoning.

[13] *Les mots et les choses*, Paris, 1966, p. 398.

[14] *Le paradigme perdu: la nature humaine*, Paris, 1973, p. 231.

[15] *Anthropologiques*, Paris, 1974, p. 9.