

HYPOTHESES ARE ONE OF THE GREAT MEANS OF THE ART OF INVENTION. GOOD HYPOTHESES HAVE ALWAYS BEEN MADE BY THE GREATEST MEN.

§.71. By distinguishing between the good and the bad use of hypotheses, both extremes are avoided, and without giving oneself up to fictions, a method very necessary to the art of invention is not denied to the sciences, a method that is the only means that can be used in difficult researches requiring correction over several centuries and the work of several men before attaining a certain perfection. And it must not be feared that by this method philosophy might become a heap of fables; for we have seen that a good hypothesis can only be made when a great number of facts and circumstances attendant upon the phenomenon one wants to explain have been observed (§.61), and that the hypothesis is only true and only deserves to be adopted when it explains all the circumstances (§.66). Therefore, the good hypotheses will always be the work of the greatest men. Copernicus, Kepler, Huygens, Descartes, Leibniz, M. Newton himself, have all imagined useful hypotheses to explain complicated and difficult phenomena; and the examples of these great men and their success must show how much those who want to banish hypotheses from philosophy misunderstand the interests of the sciences.

CHAPTER SIX

Of time

ANALOGY BETWEEN TIME AND SPACE.

§.94. The notions of time and space are very similar. In space, one simply considers the order of the coexistents insofar as they coexist; and in time, the order of successive things, insofar as they succeed each other, discounting any other internal quality than simple succession.

THE ORDINARY IDEA OF TIME IS FALSE. IT LEADS TO THE SAME DIFFICULTIES AS THAT OF PURE SPACE.

§.95. Ordinarily our image of time, as of space, is produced by confused ideas: thus, one imagines it as a being composed of continuous, successive parts, which flow uniformly, which subsists independently of things existing in time, which has been in a continual flux from all eternity, and which will continue in the same way. But it is obvious that this notion of time as a being composed of continuous and successive parts that flows uniformly, being once accepted, leads to the same difficulties as those of absolute space; that is to say that, according to this notion time would be a necessary being,

immutable, eternal, subsisting by itself, and consequently it would have all the attributes of God.

THE PRINCIPLE OF SUFFICIENT REASON PROVES THAT TIME IS NOT SEPARATE FROM THINGS.

§.96. From this idea of time M. Clarke put the famous question to M. Leibniz: *why God had not created the universe six thousand years earlier or later?*⁷⁷

M. Leibniz had no trouble countering this objection of the English doctor and his opinion on the nature of time by the principle of sufficient reason; he only needed to use M. Clarke's own objection on the time of the creation. For if time is an absolute being consisting in a uniform flow, the question of why God did not create the world six thousand years earlier or later becomes a meaningless question, and forces one to acknowledge that something happened without sufficient reason. For the same succession of beings in the universe being kept, God could make the world begin earlier or later, without thereby causing any disturbance. Now since all instants are equal, when only succession is attended to there is nothing in them that could have led to a preference for one over another, to the extent that no diversity in the world would have been caused by this choice. Thus, one instant would have been chosen in preference to another to make this world actual without sufficient reason, which cannot be accepted (§.8).⁷⁸

But furthermore, we are going to see, by the analysis of our ideas, that time is only an abstract being, which has no separate existence from things and which, consequently, cannot be endowed with the properties imagination attributes to it.

HOW ONE COMES TO FORM THE IDEA OF TIME AS AN ABSOLUTE BEING, EXISTING INDEPENDENTLY OF SUCCESSIVE BEINGS.

§.97. When we pay attention to the continuous succession of several beings, and we conceive of the existence of the first A as distinct from that of the second B, and this second B distinct from that of the third C, and so on, and we observe that two never exist together; but that A, having ceased

77. Like many of her contemporaries, Du Châtelet read Pierre Desmaizeux's French translation of the correspondence between Samuel Clarke (1675–1729) and Gottfried Wilhelm Leibniz in 1715–16 (1717 ed.). Leibniz had been the Princess of Wales, Caroline of Ansbach's tutor, Clarke was her chaplain. She asked the two men to discuss the nature of the universe and its relation to God, in particular the ideas of Sir Isaac Newton and those of Leibniz.

78. In chapter one of the *Foundations*, Du Châtelet established the basic rules governing all knowledge; in chapter two she explained that God would also choose to be subject to these rules; as a perfect being he would always have a sufficient reason for his actions.

to exist, B soon succeeds it; that B, having ceased, C succeeds it, and, we form a notion of a being we call *time*. And insofar as we construe the permanent existence of one being in terms of these successive beings, we say *that it lasted a certain time*, insofar as this being is conceived of as existing with several others that succeed each other.

So it is said that a being lasts since it coexists with several other successive beings in a continuous sequence; thus, the duration of a being becomes explicable and commensurable by the successive existence of several other beings. For one takes the existence of a single one of these successive beings for *one*, that of two for *two*, and so on with the others; and as the being that coexists with all, its existence becomes commensurable by the existence of all these successive beings.

A thousand examples can clarify what I have just said. It is said, for example, that a body uses time to traverse a space, because the existence of this body at a single point is distinguished from its existence at any other point; and it is observed that this body could not exist at the second point without having ceased to exist at the first, and that the existence at the second point follows immediately on the existence at the first. And, insofar as one gathers together these diverse existences, and considers them as making *one*, it is said that this body used time to create a line. Thus, the time is not actual in the things that last, but is a simple mode or exterior relationship, which depends only on the mind insofar as it compares the duration of beings with the movement of the Sun, and of the other exterior bodies, or with the succession of our ideas.

§.98. When we pay attention to the links between our ideas, we grasp that in the abstract notion of time the mind only considers beings in general; and that having discounted all the determinations these beings can have, one only adds to this general idea, that of their non-coexistence, that is to say, that the first and the second cannot exist together but the second immediately succeeds the first, and with no possibility of the existence of another being between the two, discounting here again internal relationships and causes that make them succeed each other. In this manner, one creates an ideal being, consisting in a uniform flow, which must be similar in all its parts, since to create it one uses the same abstract notion for each being without determining anything of its nature, and one considers in all these beings only their successive existence without caring about how the existence of one gives birth to the next.

§.99. This abstract being we thus created must appear to us independent of existing things and subsisting by itself. For since we can distinguish the successive manner for beings to exist, the manner of their internal de-

terminations, and of the causes which gave birth to this succession, we must regard time as a being apart, separate from things and able to subsist without actual and successive things, since we can still think of this successive existence, after having destroyed with our minds all the other realities, that is to say, having discounted them.

§.100. But as we can also restore to these general determinations particular ones that make them beings of a certain type, in applying our attention simultaneously to their successive existence and to their particular determinations it must appear to us that we make something exist in this successive being that could not exist there before, and that we can remove it again without destroying this being.

§.101. Time must also necessarily be considered as continuous; for if two successive beings, A and B, are not conceived of as continuous in their succession, it will be possible to place one or several between two that will exist after A has existed, and before B exists. Now by this very reasoning one accepts time between the successive existence of A and B; thus, time must be considered as continuous.

Thus our imagination creates a notion of time in considering it as a being composed of successive, continuous parts without internal differences, with which all successive beings coexist, and which becomes their common measure. This notion can have its uses, when it only concerns the magnitude of the duration and comparisons of the duration of several beings together. As in geometry one is only concerned with these sorts of considerations, so the imaginary notion can easily be put in place of the actual one. But we should refrain from making the same substitution in metaphysics and physics; for then we would fall into these difficulties of making the duration an eternal being, and with all the attributes of God, discussed above.

TIME IS NO OTHER THING THAN THE ORDER OF COEXISTENCE.

§.102. So time is really nothing other than the order of successive beings; and one forms the idea of it inasmuch as one considers only the order of their succession. Thus there is no time without true, successive beings arranged in a continuous sequence; and there is time as soon as such beings exist.

IT IS DIFFERENT FROM SUCCESSIVE BEINGS, AS THE PLACE AND NUMBER OF NUMBERED AND COEXISTING THINGS DIFFER.

§.103. But this resemblance in the manner in which these beings succeed each other, and this order that results from their succession, are not the things themselves, as we saw above (§.87.), that the number is not the

things numbered, and the place is not the things placed in this place.⁷⁹ For the number is only an aggregate of the same units, and each thing becomes a unit when all is considered simply as a being; thus the number is only a relationship of a being considered in regard to all, and however different it may be from the numbered things, nonetheless it only actually exists insofar as things exist that can be reduced to units of the same class. Once these things have been set, one can place a number, and remove it, and there are none left. In the same way time, which is nothing other than the order of continuous successions, could not exist if things in a continuous sequence did not exist. Thus, there is time when things are, it is removed when one removes these things; however, it is like the number, different from the things that succeed each other in a continuous sequence. This comparison between time and number can help to form the true notion of time; and to understand that time, like space, is nothing absolute outside of things.

GOD IS NOT IN TIME AND ALL SUCCESSION IS IMMUTABLE FOR HIM.

§.104. With regard to God, it cannot be said that he is in time, for there is no succession in him, nor can any change happen to him. Thus, he is always the same, and his nature does not vary; and as he is outside the world, that is to say, as he is not linked with the beings whose union constitutes the world, he does not coexist with successive beings as creatures do; thus he cannot be measured by that of successive beings. For though God continues to exist during time, as time is only the order of the succession of beings, and this succession is immutable in relation to God, to whom all things with all their changes are present at once, God does not exist in time. God is at once all that he can be, whereas creatures can only successively achieve the states of which they are capable.

§.105. One can accept as actual parts of time only those denoted by actually existing beings; for actual time being only a successive order in a continuous sequence, one can accept portions of time only insofar as real things have existed and ceased to exist. For successive existence makes time, and a being that coexists with the least actual change in nature has lasted the shortest actual time; and the least changes, as for example, the movements of the smallest animals, denote the smallest actual parts of time we can perceive.

79. §.87 comes from chapter five on space where Du Châtelet explains that "space" is not a "real being" but an abstraction of coexisting things, as numbers are an abstraction of things numbered. Without the things, there would be no space and no numbers, and neither space nor the numbers are the real things.

§.106. Time is usually represented by the uniform movement of a point that describes a straight line, because the point is there a successive being, present successively at different points, creating by its flow a continuous succession to which we attach the idea of time. We also measure time by the uniform movement of an object; for when the movement is uniform, the moving body will, for example, travel a *piéd* in the same time in which it traveled a first *piéd*.⁸⁰ Thus the duration of things that coexist with the movement of a moving body, while it travels a *piéd*, being taken as *one*, the duration of those that will coexist with its movement while it travels two *piéds* will be *two*; and so forth. In this way time becomes commensurable, since a ratio of one duration in relation to another can be made, with the duration taken as *one*. Thus in clocks the hand moves uniformly in a circle, and the twenty-fourth part of the circumference of this circle makes *one*; and time is measured with this unit, by saying two hours, three hours, etc.; in the same way, one takes one year for *one*, because the revolutions of the Sun in the ecliptic are equal and are used to measure other durations in relation to this unit.⁸¹

§.107. Astronomers' efforts to find a uniform motion, which put them in reach of measuring time exactly, are well known, and it is what M. Huygens found with pendulums, of which he is the inventor, and which will be discussed further on.

THE SUCCESSION OF OUR IDEAS, AND NOT THE MOVEMENT OF BODIES, GIVES US THE IDEA OF TIME.

§.108. We have seen that the successive existence of beings gives rise to the notion of time; now, as it is our ideas that represent to us these beings, the notion of time is born from the succession of our ideas and not from the movement of exterior bodies; for we would have a notion of time even if nothing other than our soul existed, and insofar as things that exist outside of us are similar to the ideas our soul creates of them, they exist in time.⁸²

Movement, by itself, is so far from giving us the idea of duration, as some philosophers have claimed, that we only acquire the mere idea of movement by our reflections on successive ideas, which the moving body causes in our mind by its successive existence with the different bodies that surround it.

80. For French measurements in Du Châtelet's day see chapter 1 (of this volume), note 29.

81. The *ecliptic* means the apparent path of the Sun, indicated by the plane of the Earth's orbit extended as if to meet the Sun, inclined to the Earth's equator by an angle of 23°27'.

82. Du Châtelet is again speaking of the *soul* in the Cartesian sense, as distinct from the body and having the properties of mind.

WE DO NOT PERCEIVE MOVEMENT, WHEN IT IS TOO FAST OR TOO SLOW. This is why we have no idea of movement when looking at the Moon or the hand of a watch, though both are moving, for this movement is so slow that the moving body appears at the same point, while we have a long succession of ideas; and because we cannot distinguish the parts of space the body traveled in this interval, we believe that the moving body is at rest. But when at the end of a certain length of time, the Moon and the hand of this watch have gone a considerable way, then our mind, joining the idea of the point where it left them, that is to say, their past coexistence with certain beings, to that of their current coexistence with other beings, acquires by this means the idea of this body's movement.

Similarly, when the moving body goes with such rapidity that we have had no succession of ideas while it was going from one point to another, we say that the moving body traveled the distance in an instant, that is to say, that it used no perceivable time. Almost for the same reason, when the impressions each of the seven colors makes on our retina are too fleeting, we do not distinguish each color in particular, but have a common sensation of all these colors, which we have called *whiteness*.⁸³

§.109. Thus only mediocre movement can give us the notion of time, because there is some relationship with the succession of our ideas; but it only gives us this notion because the soul can then distinctly represent the different states of the moving body one after another, without amalgamating several. Time, which is an ideal being, is very different from movement, which is something real.

M. DE CROUSAZ'S MISTAKE ABOUT TIME. THERE WOULD BE A TIME EVEN IF THERE WERE NO MOVEMENT.⁸⁴

§.110. Thus I cannot imagine how it could be said in a memoir that won the first prize of the Academy of Sciences (and which, moreover, has other excellent things in it), *that the existence of movement in a body is the existence of time in the body; that the time and the movement of a body are the same thing; and finally that it is*

83. Du Châtelet sent her brief "Essay on Optics" to other physicists. It bears the designation, "Chapter 4," and perhaps was intended for the *Foundations*. It certainly was part of her reading and thinking in her collaboration with Voltaire on his *Elements of the Philosophy of Newton*. See Ira O. Wade, *Studies on Voltaire, with Some Unpublished Papers of Mme. Du Châtelet* (Princeton NJ: Princeton University Press, 1947), 188–207.

84. Jean-Pierre de Crousaz (1663–1748) was a Swiss mathematician known for his adherence to Descartes and opposition to Leibniz and Wolff. In his 1721 prize essay, he wrote on the mechanics of collisions between bodies. He and Du Châtelet corresponded after the publication of the *Foundations*.

a child's notion to believe that time is the measure of rest, as it is of movement. Certainly, I could always remain in the same place and still have successive ideas; I would exist during a certain time, and I would have an idea of the duration of my being from the succession of my thoughts, even if I had never moved and never seen a body in motion, and consequently had no idea of movement. Thus, as long as there are beings with successive existence, there will necessarily be a time, whether the beings are in motion or at rest.

TIME MUST BE CAREFULLY DISTINGUISHED FROM THE MEASUREMENT OF IT.

§.111. The reason why motion and time have been confused is that time has not been carefully enough distinguished from the measurement of it.

§.112. The measurements of time taken from exterior bodies were necessary to us for putting order in facts past, present, and even to come; and to give to ourselves and others an idea of what we mean *by such a portion of time*. For the succession of our ideas cannot be used for any of these purposes; it cannot serve as a rule to us, for nothing can assure us that between two perceptions that appear to follow each other immediately, an infinite number did not happen that we have forgotten and that are separated by vast expanses of time.

Neither can this succession of our ideas be used as the means to make others understand what we mean *by such a portion of time*, because ideas succeed each other faster or slower in different heads.

WHY TIME IS MEASURED BY THE MOVEMENT OF EXTERIOR BODIES.

This is why we have been obliged to take the measurements of time outside of ourselves. Nearly all peoples agree on using the course of the Sun to measure time, and it is apparently because it seems to proceed overhead that men have confused time and movement, and for lack of a distinction between time and the measurements established for measuring its parts. For if the Sun, for example, were extinguished and relit at equal intervals, it would also serve us as a measure of time, even if the Earth and it were immobile.

THERE IS NO WAY TO MEASURE TIME VERY ACCURATELY, AND WHY.

§.113. There is not, and cannot be, a very accurate measurement of time; for one cannot apply a part of time to itself to measure it, as one measures extension by *pieds* and *toises*, which are themselves portions of extension. Each has his own measurement of time in the quickness or slowness with which his ideas succeed each other, and it is these different speeds in which ideas follow each other in different persons, and in the same person at different times, that have resulted in many ways of expressing oneself, as,

for example in this phrase, *I found the time very long*; for the time seems long to us, when the ideas have succeeded each other slowly in our mind.

§.114. It is easy to grasp that measurements of time can be different for different peoples, the annual and daily course of the Sun, the vibrations of a pendulum (which are, of all measurements, the most accurate) have provided us with those of *minutes, hours, days, and years*; but it is quite possible that other things have been used as measurements by other peoples. The only one that might be universal is what is called *an instant*; for all men necessarily know this portion of time, which flows while a single idea stays in our mind.

§.115. All measurements of time are founded only on the duration of our being, and on that of the beings that coexist with us and whose existence we view in terms of our own. For, having acquired the idea of successions and of time, although we have successive ideas, we transfer this idea to time during which we did not have any ideas as, for example, when one has fainted, and thus do we acquire the idea of the duration of the world and the universe, by relating the idea that we have of the duration of our existence to the time that passed when we did not yet exist, and to that which will pass when we are no longer.

HOW WE ACQUIRE THE IDEA OF ETERNITY.

§.116. To us the duration of all finite beings has a beginning and an end; so, if we subtract from this idea that of the beginning, then the duration is *eternity a parte ante*; if we remove the end, the kind of duration is called *eternity a parte post*, and it is thus that the soul of man is eternal.⁸⁵ Finally, if we remove its beginning and its end from the idea that we have of the duration of finite beings, the duration will become *the eternity of God*, for only God can be eternal *a parte post*, and *a parte ante*, that is to say, have neither beginning nor end. Thus, men acquire the idea of infinite duration, as of all other ideas of the infinite, by additions and subtractions, the end of which we can never see.

CHAPTER SEVEN

Of the elements of matter

WHAT WERE, ACCORDING TO ANCIENT PHILOSOPHERS, THE PRINCIPLES OF THINGS.

§.117. Philosophers from all times have exerted themselves about the origin of matter, and the elements. The Ancients each had their own different sentiment on this subject, some thought water the basic element of all bodies;

85. Again Du Châtelet has used Descartes' idea of the nature of the soul.