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Introduction

1 In the eighteenth century a renewal of natural history took place. In place of the traditional notion, according to which a mere description was the objective of this discipline, arose a new natural history concept that proposed offering also causal explanations. The best example, perhaps, of this renewed natural history, is given by George-Louis Leclerc, Count of Buffon.

2 Buffon, throughout his vast *Natural History*, published from 1749 until his death in 1788, emphasized the historical process: distribution and migration of living creatures, geological change, and he even approached the study of the degenerative changes of species along time. Buffon's endeavors are organized around a concept of nature according to which nature is a creative, dynamic agent, capable of producing by itself living creatures and the phenomena associated to

them. In other words, around a naturalistic and materialistic point of view in which God's role, if present, is limited to the creation of a "system of laws" that governs the universe. God's intervention is not needed and nature is practically autonomous. It is worth mentioning that this conception of nature did not arise in the eighteenth century but had been present since the Renaissance.[1]

3 From this new approach to natural history, everything can and must be explained through natural causes. This leads Buffon to sustain even, as aforementioned, that species can change over time, and leads him, in 1778, to elaborate a history of our planet.[2] In his work, he used fossils to reconstruct the history of the earth and of life. However, he went even further: he reasoned that in a certain period of this history, special conditions arose allowing for the spontaneous and natural generation of life.

4 Buffon divides the history of the earth in epochs. During the third, after 30 or 35 thousand years of the formation of planets, our planet reached the appropriate temperature to permit condensation of water and to allow for all the volatile matters, that the great heat maintained suspended, to precipitate one after the other to form a sea practically covering the whole globe. It is at this moment that a series of chemical combinations occurred, as a consequence of the high degree of heat. Water combined with the air, earth, and fire to form acids, salts, etc. This date marks the start of sedimentary soils formation and also that of life. Regarding this event, Buffon stated:

> *Toutes les parties aqueuses, huileuses & ductiles qui devoient entrer dans la composition des êtres organisés, sont tombées avec les eaux [...] Les molécules organiques ne son produites que par la chaleur sur les matières ductiles.*[3]

5 In other words, Buffon specifically postulated the origin of life from inanimate matter. The present work is aimed at explaining what were the most important characteristics of this "brute matter", from which living organisms were born; but, in order to understand the context in which Buffon proposed his ideas, it is necessary to glance at the way in which elements and life had been previously related.

The elements and life

6 The connections of air, fire, or sulphur with life are many in the history of chemistry. We are dealing with three histories that intermingle very early, considering, on the one hand, that the Stoics had related life with fire and air – which they conceptualized as forms of "pneuma" or active matter per se [4] – and, on the other hand, the Arab and Chinese alchemists had associated sulphur with inflammability and, through this route, with fire and heat. [5]

7 The connection of air with life is present in Paracelsus, who pointed out the similarity between life and combustion on the basis that air was essential for both processes. [6] His followers went even further and postulated the existence of a vital aerial spirit: a balsam, existing in the air, that protected the living body against decomposing. This Paracelsian perspective around the aerial spirit was not forgotten, it was later on interpreted in corpuscular terms and was again related with combustion and life by authors like Hooke and John Mayow. [7]

8 In parallel, at least starting with van Helmont, [8] the participation of air in chemical reactions started to be questioned; the air was then considered as a simple instrument of mixtures, incapable of combining with other bodies. Those who saw in air a necessary cause to start a flame thought that this action was rather due to the strange particles contained in the air than to the air itself. Among the authors that held this notion about air are Boyle, Stahl, and Boerhaave. [9] But, with Newton, the character of air was reconsidered: although for him, this element constituted the largest and inactive part of the atmosphere, it could also turn into solid bodies and these, in turn, through fermentations in which repulsive forces were exerted, into air: "Dense Bodies by Fermentation rarify into several sorts of Air, and this Air by Fermentation, and sometimes without it, returns into dense Bodies". [10]

9 This notion strongly influenced Stephen Hales and brought about that air would recover its function as constituent of bodies. For this author, air, having lost its elasticity, was found fixed in animal, vegetal, and mineral substances. In fact, in its fixed state, air formed matter, ductile and nourishing, from which vegetable parts grew. Air particles, according to this author:

> Are very serviceable in carrying on the work of vegetation to its perfection and maturity. Not only in helping by their elasticity to distend each ductile part, but also by enlivening and invigorating their sap, where mixing with other mutually attracting principles they are by gentle heat and motion set at liberty to assimilate into the nourishment of the respective parts.[11]

10 With this type of ideas, not only air and life were again interrelated; in time, Hales' experiments and theories would open the door to the conception of fixed fire, as explicitly sustained by Buffon.

11 Life was also associated indirectly to the sulphur-principle through body heat. Among Paracelsians, sulphur was sometimes conceived as an oily substance, capable of softening, and flammable; for example, Jean Béguin sustained that this principle was oleaginous and capable of preserving natural heat.[12] The gunpowder theory, which revolves around the reactions produced by the interaction between sulphur and nitre or saltpeter, in turn, provided in the seventeenth century another connection between life and sulphur.[13] From this point of view, vital heat resulted from a chemical reaction between the nitre corpuscles contained in the air, and the sulphureous particles in blood, a point of view later shared by John Mayow. Even with Newton, the reaction between nitre and sulphur finds a place; it is a fermentation that gives rise to air substances essential for respiration:

> Some sulphureous Steams, at all times when the Earth is dry, ascending into the Air, ferment there with nitrous Acids, and sometimes taking fire cause Lightning and Thunder, and fiery Meteors. For the Air abounds with acid Vapours fit to promote Fermentations, as appears by the rusting of Iron and Copper in it, the kindling of Fire by blowing, and the beating of the Heart by means of Respiration.[14]

12 During the seventeenth century, some authors kept thinking of sulphur as an oleaginous and viscose balsam, a substance capable of preserving the natural heat of organisms; but then, the sulphur-principle of the Paracelsian theory was taken over and renamed by Stahl as *phlogiston*. Phlogiston could be found dispersed in the air and under this form it contributed to sustain vegetable and animal life; it also possessed fatty and malleability qualities.[15] Meanwhile, with Hales, as the role of air changed so did that of sulphur. In the work of

this author, there are rather sulphureous particles – emitted by any body producing flames or present in substances like blood – which, possessing a strong attractive force, were capable of overcoming the repulsive force that air had when in its free state, turning it into fixed air.

> A good part of the air thus raised from several bodies by the force of fire, was apt gradually to lose its elasticity, in standing several days; the reason of which was [...] that the acid sulphureous fumes raised with the air, did resorb and fix the elastick particles. [16]

13 Fire, no less than air and sulphur, was tied to life in diverse ways. Paracelsus had stated that air and fire gave life to the animal body; some of his followers argued that fire itself contained life.

> Man has [...] an animal body and a sidereal body; and both are one, and are not separated. The relations between the two are as follows. The animal body, the body of flesh and blood, is in itself always dead. Only through the action of the sidereal body does the motion of life come into the other body. The sidereal body is fire and air. [17]

14 Likewise, nitre became to be seen as benign fire. Then, for a while just like with air, it was questioned whether fire was an element: van Helmont denied it and Descartes conceived it as a mere consequence of particles agitation. Boerhaave, in turn, did not believe either that fire could combine chemically with other bodies. In contrast, authors like Lémery, Boyle, and Homberg sustained that fire was indeed an element, that it was constituted by particles, and that it could combine with other substances. Homberg identified the matter of fire or of light, active by itself, with the sulphur-principle.

> *Nous avons un fait incontestable qui confirme ce que je viens de dire, & qui prouve que la matière de la lumière seule, & sans l'approche ou le mélange de quelque matière combustible, se peut introduire dans un corps, y rester, le rendre plus fixe & l'augmenter considérablement de poids; c'est la calcination du regule d'antimoine aux rayon du Soleil par le miroir ardent.* [18]

15 For Newton, light could be transformed into a body and vice versa (“The changing of Bodies into Light, and Light into Bodies, is very

conformable to the Course of Nature"[19]); in fact, light could react with bodies such as sulphureous ones. With time, the thought developed that the inflammability of a body was due to light being part of it; Newton's and Stahl's points of view around this topic became linked in the French chemistry of the mid- eighteenth century.

Buffon and fire

16 The previous considerations allow us to understand, at least partially, the context in which Buffon's ideas arose in regard to fire, but it is also very important to consider the great relevance that this author granted to the proposals made by Newton. In fact, for Buffon, the activity of nature – which causes all phenomena in the universe – can only be understood by using the Newtonian concept of gravity and another that he himself derived from it. Indeed, this natural activity is exerted, according to Buffon, through two fundamental forces: gravity and heat. The first moves bodies, the second vitalizes them; gravity acts on inanimate bodies, whereas heat eventually allows for the development of organized beings. Heat tends to separate all that the force of gravity tends to reunite. Whereas gravity is an attracting force, heat is an expansive force. This expansive force manifests itself as heat, light, or fire: "La chaleur, la lumière, le feu, [...] sont les plus grands effets de la force expansive".[20]

17 Now, when matter (any matter) becomes more divided or rarer, it acquires more elasticity; that is, the capacity of attractive movement, which is stretched to its limits, is transformed into repulsive. From larger to lesser capacity of movement we have earth, water, air, and fire. If the atoms of fire are the smallest and most elastic, then, we conclude that fire is the type of matter with the strongest expansive force. All matter can turn into light, heat, or fire as long as its particles are separated enough to obey without obstacles the force of gravity; at the moment that these particles collide, they will separate with such a velocity as that they had acquired at the moment of contact, thereby producing heat, light or fire.

> *La lumière, la chaleur et le feu ne sont pas des matières particulières, des matières différentes de toute autre matière; ce n'est toujours que la même matière qui n'a subi d'autre altération, d'autre modification,*

> *qu'une grande division de parties, et une direction de mouvement en sens contraire par l'effet du choc et de la réaction.*[21]

18 This point of view, which blends Newton's concepts of attraction and repulsion, has another side. Indeed, Buffon thinks that light itself can turn into any matter through the "sum of its parts" effected by the attraction of bodies. In other words, light, fire, or heat can exist in a fixed state. That is, they can be constituents of bodies. This brings about another consequence: the truly combustible matters are those in which air and fire, volatile in principle, have become fixed in such a way that they have become constituent parts, i.e., have turned into fixed air and fire.

19 At this point, the ideas of Buffon about the concept of matter reveal their roots. Although Newton's influence is undoubtedly very strong, the influence of some other investigators is quite visible. I mean thinkers that, in the very eighteenth century, had argued that every combustible body contains a large amount of the light's substance, a substance also called sulphur, and which, as we know, was one of the constitutive principles of bodies postulated by Paracelsus. Hence, Homberg stated in 1705 that "c'est la matière de la lumière qui est notre Souphre principe"[22] and, according to Algarotti, an Italian researcher, oily or sulphureous substances, inflammable, were composed of light.[23] We are dealing here clearly with ideas about the combustibility of bodies and of light as a constituent principle that go back to the Paracelsian tradition. Buffon does not only rekindle them; he recognizes explicitly the origin of these conceptions and their connection both with the chemical theory of *phlogiston* and his own ideas, that is, that of fixed fire: "Le *soufre* des anciens Chimistes représentoit cette idée, le *phlogistique* la représente dans la Chimie récente".[24]

20 But, and this is what interests us, Buffon adds in his article on sulphur, in a footnote, that fire, particularly fixed fire, the principle that the Hermetic philosophers called sulphur, is the essence of life.

> *Le soufre des Philosophes hermétiques étoit un tout autre être que le soufre commun: ils le regardoient comme le principe de la lumière, comme celui du développement des germes & de la nutrition des corps organisés [...]; & sous ces rapports, il paroît qu'ils considéroient*

> *particulièrement dans le soufre, son feu fixe [...]: dans ce point de vue ce n'est plus du soufre qu'il s'agit, mais du feu même, en tant que fixé dans les différens corps de la Nature, il en fait l'activité, le développement & la vie; & en ce sens, le soufre des Alchimistes peut en effet être regardé comme le principe des phénomènes de la chaleur, de la lumière, du développement & de la nutrition des corps organisés.*[25]

21 Fire brings about not only the development of living creatures, but also the phenomenon of life itself. Living matter is that formed by living organic molecules, active matter by itself because, first, it is animated by an expansive force that, as shown, is fire or heat, and, secondly, it is constituted by fixed fire.

22 "La force pénétrante de l'attraction jointe à celle de la chaleur produisent les molécules organiques"[26], states Buffon. He adds that the germ of an animal or vegetable is formed "par la réunion des molécules organiques avec une petite portion de matière ductile."[27] According to this, the conjunction of two forces, attraction and heat, is necessary together with some ductile matter to produce the organic molecules. Now, why is ductile matter necessary to form living beings?

23 Ductility is very important to Buffon. Thanks to this characteristic, brute matter can enter into the composition of organized beings. Let's see: the force of gravity is a penetrating force that acts inside the bodies, that penetrates in its three dimensions; but, only through heat, the expansive force, can the parts of the body extend and develop. Thus, the combination of both forces enables the ductile matter to be "worked" on in all its points, acquiring the shape of an organized germ.[28] Ductility is essential. If the attractive and expansive forces are exerted on dry and hard matters, instead of on soft and ductile matters, they can only act on the surface and not on the "three dimensions at the same time".

24 All of this allows us to return, finally, to the affirmations of Buffon in his *Époques de la Nature* In this text, he writes that the organic molecules started to exist when a soft heat could become incorporated into a certain type of inanimate matter, that is, aqueous, oily, and ductile matter. The reason why the brute matters from which the life molecules arose had to be oily, aside of ductile, is not explicitly ap-

proached by Buffon; however, as aforementioned, he thought that inflammable substances were constituted by fixed fire:

> *Le feu fixe est toujours combiné avec l'air fixe, & tous deux sont les principes inflammables de toutes les substances combustibles, c'est en raison de la quantité de cet air & de feu fixe qu'elles sont plus ou moins inflammables.*[29]

25 Oily substances were highly combustible; hence, they contained fixed fire that attracted fire in the free state. Here, the theory of chemical affinities, clearly fashionable in the 1780s, plays a role.[30] For this theory (and in total concordance with the Paracelsian principle that like attracts like), fixed heat possesses affinities with free heat, which, according to Buffon, allowed for growth and development. In relation to another subject – combustion of the diamond – he wrote:

> *La puissance réfractive des corps transparens devient d'autant plus grande qu'ils ont plus d'affinité avec la lumière; & l'on ne doit pas douter que ces corps ne contractent cette plus forte affinité par la plus grande quantité de feu qu'ils contient; car le feu fixe agit sur le feu libre de la lumière.*[31]

26 On the one hand, oily materials contained fixed fire, on the other they were soft and ductile, and, therefore, susceptible to acquire expansive movement. Probably, in this characterization of the brute substances needed for life as oily materials, were present the associations, repeatedly made by the alchemists, between the sulphureous and the oily matter; since, as Buffon himself wrote, the sulphur of the ancients was the fire contained, among other things, in the oils, i.e., the *incorporated* fire.

27 From this perspective, the oily component of the organic molecules would appear then as a sort of concentrated life, an encapsulated animation, an embodied fire. Fire would have, with respect to the rise of life from brute matter, a double role: to provide it with the expansive movement that characterizes life and to constitute it, as element, at the time of its formation. It is plausible, at least, to find in this conception an echo of the words by Paracelsus, previously cited, according to which the "astral body", that is, fire and air, gives life to the ma-

terial body. After all, the association between fire and life was an association enshrined in traditional chemical philosophy.

Recapitulation

28 According to the statement of Buffon in his *Époques de la Nature* (1778), the organic molecules constituting living creatures had a defined start and that beginning occurred when certain oily and ductile substances precipitated on the still hot globe of the earth. Life originated from these materials and from heat. But why *oily*? In one phrase, the response to this question is given by the reflections of Buffon regarding heat.

29 According to this author, heat, essentially indistinguishable from light and fire, could exist either in a free or a fixed state. A truly combustible substance was, precisely, that containing a large amount of fixed air and fire. The idea that every combustible body contained the substance of light was not at all a new notion, as was not the association or identification of the inflammability principle with sulphur and *phlogiston*. "Fixed fire", as Buffon, and the French chemists of the mid-eighteenth century, put it, in fact, constitutes a way of understanding *phlogiston*. Fixed fire, like *phlogiston*, becomes released during combustion and is part of all combustible substances. What Buffon adds, in this case, is an explanation in terms of attractive and repulsive forces, that is, in terms of Newtonian mechanics.

30 In fact, Buffon recognizes that the ancient notion of sulphur and of *phlogiston* designate both the idea of fixed fire. This recognition is important because, when he points out that already the Hermetics saw in the sulphur-principle not only the beginning of light but also that of germs development, and identifies the sulphur-principle with fixed fire, he is admitting the relation, although implicitly, between the sulphur-principle and fixed fire and life. Besides, like the Stoics and other authors closer to him, such as Homberg, Buffon considered fire to be active matter by itself. The problem here is that, from this approach, it would seem that for him life has always existed together with fire and that, therefore, no defined beginning can be assigned to it.

31 However, on the other hand, Buffon stated that attraction and heat unite to produce organic molecules, and secondly that certain ductile and oily materials are needed to form those molecules. In fact, these types of matters precipitated at a given moment in the history of the earth and, in this sense, organic molecules do possess a defined beginning. For that beginning, ductile matters were necessary because only on this type of substances can heat act as an expansive force, allowing for growth and development from the inside. Oily substances are in the first place – in opposition to dry matters – ductile and, in the second place, very combustible. The latter implies that their composition includes a great proportion of fixed fire. The fixed fire contained in the oily substances attracts the free fire, as said before, allowing for growth and development. Thereby, the organic molecules arose from the non-living matter at a given moment of the earth's history.

32 The link between fire and life established in this way by Buffon, echoes the association made by the alchemists between the sulphur-principle and oil – consecrated in the five principles system – , the identification of the sulphur-principle with fixed fire, established by French chemistry at the start of the eighteenth century, and the ties between the *phlogiston* and *terra pinguis* or fatty substances. If we join Buffon's explicit statements with those left implicit, that is, his strong debt towards the French vision of the *phlogiston* theory, we can finally understand that the oily component of the organic molecules is a sort of concentrated life.

33 If air could exist both in a free state and in a fixed state, and there was an explanation for this in terms of Newtonian mechanics, there was no doubt for Buffon that the matter of fire – the sulphur-principle of Homberg, the matter of the Newtonian light, the *phlogiston* of Stahl – could also be found fixed in the bodies. In fact, that earth, water, air, and fire could be both instruments in the reactions and constituents capable of reacting chemically was a point of view already sustained by the *phlogiston* theory as understood in France in the mid-eighteenth century. Buffon completed this perspective with explanations in Newtonian terms: the idea that attractive and repulsive forces played a role in the fixed state or volatility of a substance and that Newtonian affinity forces acted upon chemical reactions.

34 The conception held by this author on natural history took him even farther; that is, to propose – within the framework of a vision of the history of the earth as being governed by the decrease in heat – that life, only by natural forces, had begun to exist at a given moment. This moment occurred when on the still hot globe of the earth certain substances, volatilized until then in the atmosphere, were able to precipitate. Such substances were aqueous, oily, and ductile and heat acted upon them to produce organic molecules. They were oily because they were fixed fire, sulphur-principle, very ductile matters capable of attracting with great power the free-state heat and grow from inside in three dimensions at once. In his hesitant phrases on the beginning of life in our planet, Buffon drew together the ancient tradition that tightly linked fire to life.

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1 See Philip R. Sloan, "Natural History, 1670-1802", In Cantor, Christie, Hodge (eds.), *Companion to the History of Science*, London, Croone, 1989.

2 Buffon, "Époques de la Nature" (1778), In *Œuvres Philosophiques de Buffon*, Paris, PUF, 1954.

3 Buffon, "Époques de la Nature", *op. cit.*, p. 175.

4 See Stephen Toulmin & June Goodfield, *The Architecture of Matter*, The University of Chicago Press, 1962, p. 94 and following.

5 See William Brock, *The Chemical Tree*, W. W. Norton & Company, 1992.

6 See Henry Guerlac, "John Mayow and the Aerial Nitre", in *Essays and Papers in the History of Modern Science*, The John Hopkins University Press, 1977, p. 254.

7 Henry Guerlac, "The Poet's Nitre", in *ibidem*.

8 Hélène Metzger, *Les Doctrines Chimiques en France*, Paris, Albert Blanchard (1923), 1969.

9 Hélène Metzger, *Newton, Stahl, Boerhaave et la Doctrine Chimique*, Paris, Albert Blanchard, 1930, p. 248 and following.

10 Isaac Newton, *Opticks*, New York, Dover Publications Inc., 1979, p. 375.

11 Stephen Hales, *Vegetable Staticks* (1727), London, Oldbourne, 1961, p. 182.

12 See Metzger, *Les Doctrines Chimiques en France*, op. cit., p. 42.

13 See Guerlac, op. cit.

14 Newton, *Opticks*, op. cit., pp. 379-380-

15 See Violeta Aréchiga, *Fuego y vida. Fuentes del pensamiento químico de Buffon*, CEFPSVLT, México, 2007.

16 Hales, op. cit., p. 105.

17 Paracelsus, *Selected Writings*, ed. by Jolande Jacobi (ed.), Princeton University Press, 1979, p. 18.

18 Homberg, "Du Souphre Principe", in *Histoire de l'Académie Royale des Sciences*, Année 1705, Paris, 1730, p. 94.

19 Newton, *Opticks*, *op. cit.*, p. 374.

20 Buffon, "Des Élémens" (1774), *Œuvres Complètes de Buffon*, Tome I, Paris, Furne et Cie., 1839, p. 499.

21 *Ibidem*, p. 500.

22 Homberg, *op. cit.*, p. 89.

23 Algarotti, *Le Newtonianisme pour les Dames*, tome II, Paris, 1738, pp. 269-271.

24 Buffon, "Du Soufre", *Histoire Naturelle des Minéraux*, Tome II, Paris, Imprimerie Royale, 1783, p. 138.

25 Buffon, "Du Soufre", *op. cit.*, p. 112.

26 Buffon, "De la Figuration des Minéraux", *Histoire Naturelle des Minéraux*, Tome I, Paris, Imprimerie Royale ,1783, p. 9.

27 *Ibidem*, p. 6.

28 *Ibidem*, p. 5.

29 *Ibidem*, p. 114.

30 On the subject of affinities, see Buffon, "Seconde Vue" (1765), *Œuvres Philosophiques de Buffon*, *op. cit.*

31 Buffon, "Diamant", *Histoire Naturelle des Minéraux*, Tome IV, Paris, Imprimerie Royale, 1786, p. 265.

English

In this paper I try to show, in the first place, that Buffon's chemical thinking was not anachronistic but in agreement with the chemistry predominant in France before the chemical revolution of Lavoisier took place. Secondly, I try to explain why Buffon assigned an oily character to the inorganic molecules that, for him, were requisite for the spontaneous generation of life. The study of Buffon's chemical thinking allows us to see that it was part of the affinity theory, a very successful theory in the 18th century about the relationship among chemical elements. On the other hand, understanding Buffon's chemistry helps us to understand why, for him, life appeared spontaneously from inorganic oily matter; this idea is connected with a tradition in chemical thinking that considered fire as active matter. This notion of fire was kept, though disguised, in the conceptions of sulfur principle (a substance considered oily) and of phlogiston (originally "oily earth"), and finally culminated in the idea of fixed fire, sustained by the French chemistry during the second half of the 18th century. For Buffon, fixed fire attracted free fire and thanks to the movement of this element, life originated.

Français

Dans cette communication, nous voulons montrer, d'abord, que la pensée chimique de Buffon n'était pas anachronique mais, plutôt, qu'elle était en concordance avec la chimie dominante en France avant la révolution de Lavoisier. Je prétends ensuite expliquer pourquoi Buffon avait attribué un caractère huileux aux molécules organiques à partir desquelles, d'après lui, la vie se généra spontanément. L'étude de la pensée chimique de Buffon nous permet de voir qu'il s'insérait dans le contexte de la théorie des affinités, théorie qui eut un grand succès pendant le XVIIIe siècle. D'un autre côté la compréhension de la chimie de Buffon nous aide à comprendre pourquoi, pour lui, la vie surgit spontanément à partir de matières inorganiques huileuses ; cette idée est liée à une tradition de la pensée chimique pour laquelle la feu était considéré comme une matière active en elle-même. Cette notion du feu s'est préservée, déguisée, dans la conception souffre-principe (substance considérée huileuse) et dans celle du phlogistique (originellement "terre grasse"), débouchant finalement sur l'idée du feu fixe de la chimie française du milieu du XVIIIe siècle. Le feu fixe, pour Buffon, attire le feu libre, et c'est grâce au mouvement de cet élément que la vie prend son origine.

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