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The Life of the Particle: José Torrubia and the Vital Mechanics of Matter

Este ensayo explora el vitalismo en el Aparato para la historia natural de España *(1754) de José Torrubia, una obra citada por renombrados paleontólogos y mineralogistas de la Ilustración. Torrubia está ausente de los relatos académicos sobre el vitalismo, que excluyen a España y sus territorios coloniales de la modernidad científica. Su vitalismo giraba en torno a cómo y por qué distinguía la materia "muerta" de la "viva". Como historiador natural y misionero, viajó por Europa, Perú y México, intercambiando artefactos e ideas con figuras de la Ilustración de Francia, Alemania e Italia. El* Aparato *de Torrubia nos ofrece hoy una perspectiva más amplia del vitalismo ilustrado y posmoderno.*

Palabras clave: *vitalismo, materia, litología, Ilustración, Torrubia*

This essay explores vitalism in José Torrubia's Aparato para la historia natural de España *(1754), a work cited by renowned Enlightenment paleontologists and mineralogists. Torrubia is absent from scholarly accounts of vitalism, which exclude Spain and its colonial territories from scientific modernity. His vitalism turned on how and why he distinguished "dead" matter from "live" matter. As a natural historian and missionary, he travelled throughout Europe, Peru, and Mexico, exchanging artifacts and ideas with Enlightenment figures from France, Germany, and Italy.* Aparato *offers us today a broader perspective on Enlightenment and postmodern strands of vitalism*

Keywords: *vitalism, matter, lithology, Enlightenment, Torrubia*

The alleged underdevelopment of the Spanish life and material sciences during the eighteenth century is by now a cliché characteristic of scholars who have not read anything since the nineteenth century. Jesús Pérez Magallón's *Construyendo la modernidad* was pivotal to the Spanish world's reversal-of-fortunes within the critical history of science. It put to bed the myth that Europe outside of France and Great Britain was an Enlightenment desert with a few shrubs and watering holes here and there, but no means to support human culture. Not only was Spain not bereft of modern scientific ideas, but scientific modernity and scientific knowledge, more broadly, have been shown to be fitful processes, rather than a revolution, following zigzagging trajectories, rather than a straight line. The amorphous and fissured character of scientific modernity should also not be attributed to a clear-cut divide between Protestant and Catholic, or between organized religion and science. Within the early modern life and material sciences there were conflicts that transcended differences of faith and in fact drew sustenance from trans-national and trans-religious exchanges. Such were the pitched battles between vitalists and mechanists. These battles led to methodological and conceptual reconciliations, namely, vital mechanics, that might offer a corrective to current scholarly models of Enlightenment vitalism as well as food for thought to neovitalists and neomaterialists in the aspiring posthuman humanities (Gamble, Hanan, and Nail 111-34; Sparrow; DeLanda; Aloi; Bennett).

For vitalists in the seventeenth and eighteenth centuries, living matter was imbued with some immaterial force or virtue which transcended or perhaps instrumentalized the mechanical laws of motion. Like contemporary new realism (Ferraris) or new ontological realism (Gabriel), eighteenth-century vitalism assumed that the existence of objects in the external world was not dependent on the human subject's knowledge of them. Vitalism assumed something else too: animate matter was different from inanimate matter. Further still, the generation, growth, and death (or corruption) of organic things could not be explained by mechanical philosophy alone. There was more to life than matter and the laws of motion.

Scholarly attention to the vitalist controversy in eighteenth-century natural philosophy, geography, cosmography, and natural history has grown in the 2000s, but nothing comprehensive is known about Enlightenment vitalism *per se*. Even the most illuminating studies do not venture beyond Germany, Great Britain, and France (Reill; Sloan; Williams). In the life sciences, the Edinburgh and Montpellier schools were influential and are perhaps the best known. Precisely because we do not know what vitalism looked like outside of those geographical parameters, I would not even hazard a guess as to what Enlightenment vitalism was as a whole. I do know that Enlightenment vitalism cannot be retrospectively characterized as a reaction to mechanical, iatromechanical, and iatrochemical philosophies. That "vitalism is a theory which understands life in terms other than physical, chemical or mechanical" (Packham 209) is not true of mid-eighteenth-century vitalists as a cadre.

Many vitalists were engaged with "physical chemistry," as they called it, and schooled in different schools of mechanical philosophy. These vital mechanists were determined to discover the universal laws of the life sciences as well as the internal operations, or *mechanism*, of things. Their engagement in mechanism-discovery was readily apparent in what we today call anatomy, botany, zoology, mineralogy, chemistry, and paleontology. On this score, at least, their vital mechanics of matter shared a conviction with the *new mechanism* formulated by practicing philosophers of science today (Craver and Tabery; Glennan). Still, the methodological and conceptual depth of their vitalism is indisputable, and the vitalists who appear in this essay prove that the concept of active matter was present in Enlightenment vitalism (for the opposite view see Packham 4-5, 14-15, 208-9). The complex interface of mechanical and vitalist frameworks exerted a fascination on them and has been shortchanged in histories of vitalism and in current cultural-theory movements such as new materialism and new vitalism.

The "vibrant matter" of Bennett's object-based ontology rests on the conviction that the matter which makes up us as well as the universe is never at rest and always in contact. Contemporary philosophers and scholars across many disciplines have discovered myriad opportunities to disrupt the ontological divide between human and non-human. Theorists of new vitalism and of object-based ontology consider that the ordering or disordering of organic bodies into three (artificial) natural kingdoms is a cultural construction of nature that severs human matter from non-human matter. On this account, the three kingdoms of nature are in fact artifacts, or human-conceived assemblages of artifacts, in which the movement or erasure of one object within the grouping impacts other objects and the assemblage as a whole (DeLanda). Thus, the three kingdoms of nature are culturally assembled as alive, or active matter.

My entry point into the vital mechanics of matter is the renowned naturalist José Torrubia, a missionary who lived and collected fossils across Peru, Mexico, the Philippines, Spain, and Italy, before he published *Aparato para la historia natural de España* (1754) (Pelayo 188-97). Ontologically and epistemologically, Torrubia's text unfolded through the reciprocity between local, practical know-how and discursive, or theoretical, knowledge (Ryle; Cooper; DeLanda). It aspired to be an illustrated description of Torrubia's natural history cabinet and at once a framework for writing a natural history of Spain. Along the way, Torrubia enacted how one should study nature and write natural history and tied his *museo*, or cabinet, of natural history, to controversies in physics, chemistry, and theology. Before turning to the eighteenth-century vital mechanics of Torrubia and his cohorts, I want to briefly survey a tenet that has fallen out of contemporary vitalism and materialism, although it was crucial to vitalism from the seventeenth century to the early twentieth century: *why and by what means matter moved*.

MOVING MATTER: THE INTERIOR-EXTERIOR THRESHOLD OF GROWTH

As it is for new materialists today, the relationships between bits of matter and their movement in the formation (or "generation") of material objects was fraught with metaphysical, physical, chemical, and methodological unknowns for Later Scholastic authors. The most vital function of animal and plant life was nourishment, or nutrition (*nutritio*): the reception, conversion, and distribution of matter for development according to species. The *mechanism* charged with nutrition was the fulcrum of metaphysical discussions around rational, sensitive, and material souls, for without a mechanism there could be no function. The physical and metaphysical concept *per intus sumptionem*, "by taking from inside," was bequeathed to Enlightenment vitalists, non-Scholastics and Scholastics alike, by Jesuit theologians and natural philosophers such as Francisco de Toledo, Francisco Suárez, and Rodrigo Arriaga (Des Chene 57-63; Demarest and Wolfe *passim*). The distinction between growth engineered from within, by *intus-sumptio*, and from without, by *iuxta-positio* or *extra-positio*, was common in early-seventeenth-century attempts to grapple with concepts of vital action, agency, and continuing causes.

In this brief overview I reduce the magnitude and complexity of those discussions to this Second Scholastic tenet: in the vegetable and animal kingdoms, *intus-sumptio* was predisposed by the immaterial life force; the latter set in motion the regulated and systematic movements of nutrition, growth, and development in living things. The vital force inhering in living matter enabled *intus-sumptio*, the very mode of physical motion and growth that distinguished living things from non-living things as a class. When he, French professor of philosophy François Le Rées, defined *intus-sumptio* in his handbook of metaphysics (30-34), he held that an internal motion of their own, inanimate objects could not agentially form a new substance; they could only be acted upon or compelled to form new substances. Inanimate things grew as their external parts came into random contact with opposing surfaces of other inanimate things and the mixture of fluids united them, without any internal organization of matter or limits on dimensions (123). Echoing Arriaga, who attributed the ordered growth of plants, animals, and even teeth, "in latitude and longitude," to *intus-sumptio* (557, 564, 568), Le Rées insisted that all living things, even bones and teeth were endowed with a life force that warranted their systematic and regular development from *intus-sumptio*. This predisposed physical development is what it meant to grow vitally. Non-living things could grow only by juxtaposition, and clearly teeth grew from within (*intus-sumptio*), not from within out (*iuxta-positio*), as did hair and nails also (Le Rées 34-40). Living things and non-livings differed in that motion was immanent in living things, on Arriaga's account (564). Likewise, Le Rées argued that the physical life (*vita physica*), or material body, of livings things did not exist without the ordered operations, or motions, of *intus-sumptio*, although living things could also be set into motion by external force.

In Italy Arriaga's influence was felt too. The physician and experimental chemist Lodovico Maria Barberi not only discovered that a gas (oxygen) was necessary for living beings to survive, but also rejected the notion that stones were living things that could increase, or "grow." What appeared to be growth, he argued, was nothing other than *coadunation* - the joining of crumbly or tartar-like particles. Stones did not have *intus-sumptio*; they were not nourished by the fermentation of nitro-ethereal spirit and sulphur as occurred in human blood (Barberi 80-83). "[n]ourishment, properly speaking, is a vital work (*opus vitale*)," wrote another French vitalist, the renowned Dominican Antoine Goudin. He defined *nutritio* as "the conversion of alimentary substance into living substance" (Goudin, *Philosophia* 369-70). Plants and animals increased by *intus-sumptio* whereas non-living things increased by *iuxta-positio* (*Philosophia* 369-70). In Spain, the Franciscan theologian and philosopher Juan de Merinero y López upheld the same distinction between animate bodies (those that are nourished and that increase by *intus-sumptio*) and inanimate bodies (those that increase by *iuxta-positio* only) (154-55). From my brief overview here, there emerges a semantic and conceptual continuity around why and how matter moved, and, more narrowly, around how the internal organization of a living thing was predesigned to perform life functions. Before the nineteenth century, in fact, "organism" and "organic" denoted *order*: it was believed that an ordering ("organic") mechanism did not exist in nonliving things.

ROCKS OR REMAINS? PROLOGUE TO A VITAL MECHANICS

By the end of the seventeenth century, it was not possible to dismiss the potential growth of stones and gems, as those Later Scholastics had rejected it. Geological origins and human origins, as well as mineral and plant growth, were being framed in unexpected ways. The recovery of sea shells, pieces of petrified wood, and precious stones from mountaintops, dried-up riverbeds, sand, and soil perforce touched on the surfaces, internal mechanisms, and classifications of stones, precious metals, and other members of the mineral kingdom. For many authors around the turn of the eighteenth century, the increase in size and the asymmetrical configuration of certain minerals suggested that the substance that constituted them was alive. Some chemists, naturalists, and physicians attributed this activity to a seed or a plastic virtue activated by fermenting liquids bubbling up from the ground beneath them, which organized the growth of rocks. Several other vitalists thought otherwise, arguing that such rocks grew only because other rocks became attached to their surfaces, which external growth must be understood mechanically, through the laws of motion. They conceptualized rocks similarly to how a skein of contemporary ontology (Baker) conceptualizes *aggregates*, which derive their identity from the kind of matter that constitutes them, rather than from a specific arrangement of their matter.

That was the backdrop to physical and metaphysical debates about the origins of fossilized marine life and why they were found on mountaintops, in caves, and in cleaves distant from sea waters. Vitalist mechanical frameworks and models arose from such *querelles*. Some natural philosophers argued that marine fossils and animal bones were not the decomposed and petrified remains of life, but rather rocks. Others, however, insisted that fossilized vegetable life and plant life were ontologically distinct from minerals.

In the substantivized universe in which José Torrubia and his cohorts lived, substance was active (Reill 81), but the cause (or agency) of active matter and the mechanisms through which it unfolded were extremely complex. Torrubia's prologue quickly set the tone. First, he availed himself of the French translation of John Locke's *Essay on Human Understanding* to argue that universal laws of physics might be unattainable for a good part of the natural world. If it was hard to reason with certainty about animals, minerals, and vegetables that we can touch, how could we possibly hope to understand "the extraordinary and rare mechanism behind things that appear to exceed the very limits of nature"? How would physics be able, "without the light of reason or of experience," to go looking for Nature in "the hidden workshop where she works with free hands the wise artifice of her productions?" (Torrubia 1).[1] Nature crafted the material bodies, or things, in the external world, which operated with unfailing regularity ("her power is immutable") through internal mechanisms (3). Still, the best that one could offer sometimes was an observation-based conjecture about a natural phenomenon. For example, the sea is perpetually in motion, but the "Mechanism" designed by God for the ebb and flow is unknown and perhaps unknowable (185).

Second, Torrubia set out what we today call *dynamic modelling*, i.e., going back and forth between the phenomenon and hypotheses about its operating mechanism. It is in fact characteristic of the *new mechanism* unfolding today in the field of philosophy and history of science, which focuses on data and practices, rather than on abstraction and theory. He issued a clarion call to experimental natural historians, promising to follow the path cut by Francis Bacon through the *sylva* by reasoning from nature, rather than applying theories to nature, and by writing a narrative, or "history," as Bacon called it. We had to follow Locke and Bacon in applying our human senses to the phenomena, studying "the effects" and conjecturing about "the hidden causes." These were the "mechanical laws of God" (5). Thus, already in Torrubia's prologue, there surfaced the admixture of mechanicalist and vitalist principles that readers find later in *Aparato*.

Torrubia's alliances and disagreements with vitalists and mechanicists quickly came to light as he reflected on "fossils," a concept that ranged from ancient bones and flints to petrified tree branches, fossilized marine organisms and plants, elephant and alligator teeth, and mummified human remains. He explained how in ancient times fishes had become buried in white sandy hills, where the sand became petrified and "incarcerated them in its bosom" (11). "There it preserved them, not only intact but also embalmed – or, to put it better, reduced to some sort of mummy, like those that they bring back from the sands of Ethiopia" (11). Torrubia paused on the organization of sandy rock: "The structuring of this stone is reduced to two sheets, like pieces of slate although not as solid, on each of which, after easily separating into two halves, half of a fish is imprinted, with the two perfectly forming the identity of the fish that was anciently imprisoned there" (11). Intentional or not, this transition between non-human and human conveys to us a vital materiality that does not *decenter* the human (Aloi 196-197, responding to Bennett, *Vibrant Matter*). Nonetheless, such explanations might imply a counterweight to the biopolitical dominion of human agency known as the Anthropocene. Without foregoing the vitalist distinction between animate and inanimate objects (much less the vitalist construction of the mechanisms of nature), Torrubia's explanation of organic change was epigenetic: the inanimate (sand, rock, and other minerals) interacted with animal and vegetable, serving as an intermediating cause in their decomposition and recomposition into some other state of matter.

Torrubia's experimental physics guided his assemblages – his interpretation, arrangement, and display of natural objects, because vital force operated through mechanisms that human understanding could access only through their perceptible effects. He gathered data and made conjectures "as Monsieurs [Comte de] Buffon and [Ferchault de] Réamur do," based on "mechanical experience," or direct observation and controlled experiments (Torrubia 13). The petrified specimens that he had dug up in Spain were not minerals that had *only the shape* of marine creatures: they were actually sea animals in an altered state of matter. Torrubia's vital mechanics upheld the regularity and predictability of the biological world: "It is certain that the imperturbable mother [of nature] operates with laws in all she does, and that she does not violate them even when she errs" (25). On such universal laws of matter and motion rested the "especial orgánica configuración" of each specimen, which was undeniable (Torrubia 25). His usage of "orgánica" in this phrase is highly significant. What the noun and its two qualifiers ("especial" and "orgánica") together convey is that the configuration of each marine specimen is *specific* (i.e., developed in fulfillment of its kind or species) and ordered like a living thing ("orgánica," or predisposed for life functions). To seriously entertain the theory that such fossilized creatures were "Nature's whims," or rocks formed by chance, "would be to reduce to happenstance Nature's serious universal productions, to the discredit of the steadfast principles by which she acts" (Torrubia 25). It would be to render the living, dead.

Previously, I asserted that *why and how matter moved* was central to Later Scholasticism's understanding of the animate and the inanimate. It should come as no surprise, then, that Torrubia conceptualized essential dissimilarities between the internally animated (animal, vegetable) and the internally inanimate (mineral). He scolded a priest, high in the mountains of Spain where Torrubia had gone to collect marine fossils, who insisted that rocks grew like plants, that there were quarries in which "they bred and they grew just as tubers and mushrooms do" (25). Torrubia corrrected the priest: "all of the testaceans that are found on land had at the time of their formation their living Residents proper to each species" (26). All of them had their "ancient renters" or "inhabitants" who lived and died. Those shells were not "procreated in the ground," and they did not "continue growing due to an intrinsic force that Nature communicates to them" (26-27). This passage imparts two lessons: one, those shells were neither minerals nor vegetables; two, rocks were not born and could not develop from "an intrinsic force" as mushrooms developed.

Torrubia insisted that stones shaped like crabs, with impressions that looked like various kinds of marine life, were not nature's whims or accidents, but in fact fossilized marine specimens. Torrubia was familiar with Scheuzcher, a declared vitalist who viewed fossils as the remains of organic life. The Swiss and the Spaniard both argued that marine life was carried from the bottom of the seas during the biblical Flood and came to be deposited inside the Earth and on mountaintops. There they became petrified due to the universal laws of physics, according to Schuezer, Bourguet, and Torrubia. A marine organism's material structuring of matter, liquid or solid, intervened in the solidifying of marine organisms. These "mechanisms" (Torrubia 97) followed universal laws of matter and motion, Torrubia argued. But these were not the ultimate cause, which was vital force, or nature. He wrote of his "museum," or cabinet: "Upon each and every one of these specimens, Nature has impressed its characteristic shape; [each] has been formed with fixed and universal laws, in the sea, which is the originary and connatural bosom of each and every one of those testaceans, with [nature] providing the exact and individual mechanism that out of necessity all individuals of the same marine species have" (97). Each of the petrified shellfish specimens that he preserved in his monastery cell developed the shell distinctive to its kind through a mechanism that organized and distributed juices containing particles of matter through the pores of its texture and gave the shell the colors and shapes of its species. This did not happen inside the soil or the rock, nor on the surface of either. Instead, its "variegated, gorgeous, and required mechanism was devised in the same salty workshop, and by the same hand" (97-98).

Notwithstanding the term *mechanism*, Torrubia's biology and chemistry were not mechanical in the sense that scholars of the history of philosophy and science routinely assume when they see *mechanism* (see, for example, Allen). While discussing whether shellfish and other marine creatures could have travelled to all four continents during the Flood, he promised to "reflect with that serious and anatomical judgment with which these matters must be addressed, on the Mechanism with which the Author of Nature constructed these individuals" (Torrubia 195). For Torrubia, the material structures charged with the functions of nutrition and development in marine life obeyed universal laws of nature. By mentioning anatomy, however, Torrubia brought attention to the material aspect: the concept of mechanism was that of a material organized toward a specific function. It coincided with the fiber theorists and anatomists such as Grew and the experimental chemist Thomas Willis, the latter associated with both mechanical atomism – materialism – and chemical vitalism (Roux 34). To better grasp what Torrubia meant by that phrase that I cited earlier, "especial orgánica configuración," it is necessary to delve into the *organic mechanism* concept that informed his practices and modelling of vital mechanics.

ORGANIC MECHANISMS AND THE PHYSICS OF MATTER

Torrubia used the phrase "Savants of Montpellier" numerous times. The School of Medicine in Montpellier was Europe's oldest, and it was indebted, like all other vitalist institutions in the seventeenth and eighteenth centuries, to Pierre Gassendi's vital materialism – the combination of mechanical physics and vitalist physiology. To study medicine at Montpellier was to study biology and dissection, which the graduate could thereafter apply in fields ranging from botany, lithology, and zoology to pharmacology and human pathology. Torrubia mentioned physicians-turned-botanists numerous times. Among them are Joseph Pitton de

Tournefort, who had studied medicine at Montpellier before becoming the director of the Royal Garden in Paris, and Antoine de Jussieu, who had studied medicine at Montpellier, then succeeded Tournefort as director of the Royal Garden, and published groundbreaking studies on botany, mineralogy, and zoology. Étienne François Geoffroy, who had studied medicine and pharmacy at Montpellier, was especially relevant to Torrubia's physico-chemical methodology in lithology, or the study of rocks. Torrubia also praised physician and anatomist Francisco Vidal, a member of his own order who had taken his degree in medicine from Montpellier. Vitalist naturalists and collectors associated with Montpellier's Royal Society of Sciences, such as Antoine-Joseph Dezallier D'Argenville, informed Torrubia's classification of marine fossils and rocks. Nonetheless, references to Italian savants are ubiquitous in *Aparato*. The link between these two sets of vitalists resides in the forgotten fact that Montpellier's most prominent eighteenth-century vitalists studied, collected, and lived in Italy's centers of medicine and antiquarianism: Florence, Padova, Bologna, and Rome.

Torrubia rejected outright Pitton de Tournefort's "system," to wit, the system-theory that stony coral (*madrepora*) and coral "are propagated from seeds like true plants … [and] this method of reproduction must have transcended to other stones as well" (38). Jussieu, Réamur, and, more recently, Vitaliano Donati, had discredited Tournefort: these so-called "marine plants" were, in fact, marine *animals* (Torrubia 38). Torrubia also dismissed the theory that such fossils grew within the chinks of rock formations or on top of them by a plastic force (46) akin to that which moulded the generation of animals and vegetables (Rudwick 14). He again repudiated "the weak opinion of seeds [generative] of stones" (Torrubia 46) associated with Tournefort since the turn of the eighteenth century (Pelayo 95-97).

Torrubia emphatically separated rock from mineralized bone. He used a microscope to examine a cranium and other human bones that he had excavated in Teruel. The bones were petrified, their marrow became crystallized, and its parts took on "an invariable determined configuration" (Torrubia 50). This was not by chance. He thereafter attempted to explain "the cause of this mechanism" by reviewing the geometrical shapes that chemical elements and metals assumed through crystallization (50-51). Torrubia recalled Antonio Vallisneri's vitalist argument that nature disposed "to configure crystals and stones under a certain principle that he wished to call Seminal and Vegetable" (*Aparato* 52). That principle – i.e., ordering – caused them to maintain the same uniform shape as they grew. It was the mechanism that explained and ensured the isomorphism of each kind of crystal. Torrubia repeated twice that Nature crystallized these microscopic geometrical patterns with unfailing regularity, in accordance with each region. So, for example, the geometrical pattern of one and the same kind of crystal varied from Rome to Spain and France. This did not at all alter the fact that in one and the same region the interior of all individuals or members of that kind of crystal would invariably show the same shape as determined by nature's uniform laws (52-53).

Louis Bourguet, a disciple of Vallisneri and a dear friend to the renowned Swiss naturalist and historian Johann Jakob Scheuzcher, figured heavily in Torrubia's depiction of crystals. Although Bourguet is remembered today for his reconciliation of Nehemiah Grew's and Gottfried Wilhelm von Leibniz's metaphysics and physics, there can be no doubt that he was heavily indebted to the Italian anatomists, fossil and mineral collectors, and natural philosophers such as Antonio Vallisneri, with whom he corresponded and alongside whom he collected specimens during some 12 years spent living in Italy. His works on the formation of salts and crystals (1729) and petrifications (1742) appear again and again in *Aparato*. The rule of thumb for distinguishing between fossilized life and rocks was as follows: the microscopic examination of both proved that the former presented uniformly organized structures whereas the latter did not. The closest that stones came to physical uniformity was seen in crystals, in which one detected the geometric regularity of each kind of mineral (Bourguet, *Lettres Philosophiques* 7).

Bourguet's biophilosophy was thoroughly vitalist, but it should not be confused with hylozoism: he distinguished between inanimate and living matter, by framing Leibnitz's monad and harmonies as *organic mechanisms* (Wolfe, "Why" 200). Such mechanisms were responsible for that vital and uniform organization of plants and animals that minerals lacked. Although we could not see the infinite varieties of different molecules or the overall structure and laws organizing life, we observe natural phenomena and employ human reason with precautions and exactness to form conjectures in physics. In the mineral realm, certain kinds presented a great analogy with kinds in the vegetable realm, due to the material fluid that took part in their growth. A prime example was a crystallization known as a stalactite, which Tournefort had mistaken for a vegetable kind – a tree (Bourguet, *Lettres Philosophiques* 36-39).

"The general laws of motion," Bourguet stated, "and the shape of molecules that constitute these curious productions suffice to mechanically explain their formation" (41). These laws, he specified, were reducible to gravity, "which is an immediate effect of the Mechanical construction of the World" (Bourguet 41). God's construction of the Universe provided for these mechanical operations of material particles or molecules, in liquid or solid state, which came together and broke apart as explained in Newton's laws of attraction or Leibnitz's "conspiring movement" (50-51, 59). The geometrical uniformity of a stalactite notwithstanding, it was an "accidental concretion" (64) caused by the general mechanism shared by all things that were not animals or vegetables, members of which two kingdoms possessed the "organic mechanism" particular to each kind (72). A marine organism such as a shell presented uniformity as a concretion because God had endowed animals with a material structure and laws that ensured vital functions: "un *Méchanisme Organique"* without which they could not exist (64). The inorganic object increased by layers, on the outside, whereas the organic object grew by the addition of molecules through its interior all at once (71).

God endowed all bodies – all things – in nature with a specific organizing principle, or order: *organisme*. In Grew and Bourguet this organizing principle was imprinted on every body, or organization of matter, in the universe (Bourguet *Lettres Philosophiques* 327-28). All of nature was composed of corpuscles or molecules, endowed with "a vital activity" fitting their shapes (66). Their combinations were infinite. Each could change in line with the natural linkage of the activity of the particular corpuscle and of the systematic composition of all of them assembled (66-7). Not all organized bodies, however, had also a vital or non-material ordering principle. Each organized thing, therefore, internally differed in fulfillment of its divinely instituted purpose. Thus, the less-organized object did not have an organic mechanism, the internal structure in living beings that fulfilled activities such as nutrition and development according to kind. The birth and growth of internal organs and the circulation of fluids through them was instantaneous and on-going, because God created plants and animals with this organic mechanism or structure for life functions. Growth, nutrition and development were linked together as effects, like self-directed movement, of the organic mechanism (147). Stones were not divinely disposed or arranged to develop from the inside out.

PHYSICAL CHEMISTRY, OR THE GENIE AND GEOMETRY OF MATTER

While Bourguet's mechanico-vitalist lithology was pivotal to Torrubia's chapter, "How Rocks in Quarries Grow," vitalist chemistry also left a deep imprint on Torrubia's mechanism of crystallization. The aforementioned Geoffroy was the most renowned French chemist of the first half of the eighteenth century. He integrated Cartesian mechanicalism into chemistry, but his experiments in the laboratory were geared toward the practices of apothecaries and physicians. His *Table des rapports* (1718) laid out the affinities (*rapports*) between substances, i.e., which substances were regularly disposed to react with other substances. It secured his reputation not only as an academic chemist, or *chémiste savant*, but, retrospectively, as the founder of modern chemistry (Joly, *Étienne-François Geoffroy*). Torrubia's *Aparato* reflected the tripartite discipline of medicine at the French Royal Academy of Science in Paris: chemistry, botany, and anatomy, and how chemistry aspired within the Royal Academy and at the Royal Garden, to compete as an experimental knowledge field (Kim). Additonally, *Aparato* testified to the exchanges between vitalist chemists at the Royal Academy such as Geoffroy, who was also a physician, and Wilhelm Homberg, and to the prominent influence of the German vitalist chemist Stahl (Ku-ming Chang; Kim). Torrubia was one of many mid-eighteenth-century vitalists on the European continent who embraced Stahl's and his disciples' stance that mechanical physics was not superior in its mathematical, universal laws of matter and motion to their own physico-chemical understandings of composition and decomposition of material bodies in the substantivized universe (Reill, 74-76).

The *mechanism* that Torrubia promised to explain for the growth of stones in quarries was a material conduit between the life force and the matter that it put in motion in organized and uniform steps that were mostly hidden from our senses. *Aparato* makes evident how impactful Geoffroy's physico-concept of mechanism (Joly, "Chimie et mécanisme") was: "Mr. Geoffroy and others reduce the present subject of mechanism to earth and water. To earth they attribute two kinds of molecules, or primitive particles, from which earth originates by nature" (Torrubia 118). I suspect that the chemists Homberg and Stahl were "the others" in "Geoffroy and others" (although Torrubia did not, as I show later, accept Homberg's thesis that rocks grew like plants did). The first molecules are some extraordinarily minute, thin and uniform sheets; the second (although they too are extraordinarily delicate) have irregular shapes.

The first kind are molecules containing salt or oil that bind together in sufficient quantity; thereafter, their inherent identity ("nativa igualdad") fixes and uniformly disposes them, by means of their salts and oils, to form homogenous composites, or natural objects, that are diaphanous, transparent, and hard. These imperceptible flat surfaces, or sheets, of particles are compactly joined together, so they form bodies (to wit, crystals or minerals) with hard, transparent, and shiny surfaces. Crystals, diamonds, and other stones in this class were composed exclusively of this first kind of earth molecule. When the second kind of earth molecules (those of irregular shapes) come together by the same principles, they form bodies that are opaque and less hard. All other stones were composed of various mixtures of the first and second types of earth particles. The internal composition of agate, for example, was first kind of earth molecule, while earth particles of the second kind covered its rough surface (Torrubia 118-19).

Torrubia skated between the agential and the acted-upon: following Geoffroy and like-minded savants, Torrubia asserted that the inherent identity ("nativa igualdad") of the first kind of earth molecules uniformly disposed them to form a homogenous composite. Of the latter, he specified, "[i]t is hard because those molecules or particles por su genio come together and all of their parts become immediately linked upon contact" (Torrubia 118). The tricky question, which is crucial to not only vital mechanics but also to contemporary iterations of vitalism, is: what did this untranslated *por su genio* mean? I surmise that *genio* in this context was what Geoffroy meant by affinity or attraction (*rapport*) – i.e., the shared identity or immanent character of a substance that determined that it would strive to combine with another substance. I find evidence for my reading in the renowned Dutch vitalist Hermann Boerhaave, cited often in *Aparato*, who posited the existence of immanent properties in matter. His concept of immanence would spur physicians many decades later to open new pathways in vitalist medicine (Knoeff). It could be said, then, of Torrubia, what has been said of natural philosophers from the later eighteenth century: "the separation of principle, power, or force from substance appeared a contradiction in terms" (Reill 81).

Vital force was immaterial, but it did not hover above the elements and chemical compounds that we call stones: it was in them. For Torrubia's chemical authorities, what he translated as chemical composition *por genio* rendered matter active – a sort of Lockean "thinking substance" or genial molecule that recognized its affinity or relationship of identity with other substances or molecules. Other vitalists indebted to the chemists Homberg and Geoffroy had tried to elucidate what Torrubia had called "the mechanism of configuration" in stones (Torrubia 47). One of them, the naturalist and antiquarian Johann Ritter von Baillou, decisively contributed to Torrubia's blend of mechanical and vitalist philosophies.

Jean de Baillou, as he was known in his early years, was a child of the Hapsburg and Bourbon empires and a forgotten nexus of Italian, German, Spanish, and French cultures of natural history and natural philosophy. Chévalier de Baillou was the son of aristocratic parents from Flanders, although his birthplace remains unknown. Educated in Paris, he spent most of his adult life within the circles of Italian antiquarianism, medicine, and natural history. Decades before the Austrian emperor Leopold purchased De Baillou's cabinet of natural history in Florence, laying the foundation for today's Natural History Museum in Vienna, *il Signor Cavaliere Giovanni de Baillou* served as the director of gardens and garrisons in the different regions of Italy that corresponded to his patrons. In 1747, he offered to members of Florence's Società Colombaria his *Mémoire présenté*, an explanation of his methodology, a minute description of his museum, or cabinet, of natural history, and a brief treatise on lithology, conchology, and mineralogy based on his cabinet.

In a lengthy narrative in French and Italian, Chévalier de Baillou highlighted the crucible of the senses that demarcated human cognition of the natural world. Like Torrubia later, De Baillou appropriated John Locke's *Essay on Human Understanding* at the onset of his discourse. He went on to claim that he first used his senses to observe mineral specimens in their natural state, then turned to instruments (De Baillou 193). His analytical method espoused "the alliance of geometry and physics": he performed observations and experiments on nature, in the "geometrical spirit" (195-6). This "mechanical method" in natural history – the very phrasing used by Torrubia, as I already remarked – was a "geometrical analysis of Nature" that resulted in exactness and took little time, he insisted. Instruments allowed one to see, with the eye of the intellect, the internal organization of natural objects that escaped human vision (196). Chévalier de Baillou's foray into metaphysics concerned classification of the specimens in his *musée*, for which he joined microscopy to experimental chemistry: "Like Messieurs Homberg and Geoffroy, philosophers similar to Prometheus, who have discovered how to strip the sun of fire, I have availed myself of the burning mirror and the astronomical telescope to push my analyses, with the assistance of a most penetrating chemistry, as far as I could" (201). As De Baillou elaborated with pride on all that his "physical chemistry" was able to do for society – for mining, art, medicine, horticulture, agriculture, architecture, jewelry – he promised "to demonstrate the existence of petrifying juices in petrifications" (195). This core belief was supremely important to Torrubia's own mechanical method.

PETRIFYING JUICE AND THE DISORDER OF ROCK

As trivial or arcane as it seems today, the role of liquid in the petrification of vegetables and animals and in the "increase" of minerals was fiercely contested in the eighteenth century. In an enormously influential and controversial dissertation on the "vegetation of stones," Giorgio Baglivi presented a system-theory according to which stones grew like plants: i.e., they "vegetated" (296-336). His vitalism classified as organic objects some of what we in the West today classify as inorganic objects. Thus, if contemporary vitalists such as Bennett aspire to decenter the human and confer agency on non-living things, Baglivi's vitalism decentered the human and conferred agency on (some) non-living things because he understood them to be in fact living things. Torrubia, in contrast, qualified as ridiculous the notion that “stones are born and grow,” that “stones are formed by generation and maintain a successive internal increase until they become high hills” (117).

He seized upon the controversy over juices and growth to distinguish between the internal organization of plants and minerals. In plants, the juice composed of little parts or molecules carried by water did not have a proper name, but this sort of vegetative juice made plants grow due to some vital disposition or life force of their own. We know what it does, he asserted, but we do not know what it is called. In stones this was known as the petrifying juice, and when a marine specimen fell into it and the petrifying fluid evaporated, the marine specimen was turned into stone (Torrubia 121). Baglivi was wrong to theorize that stones came into being out of a juice that fed its internal seed and Vallisneri – whose son was on good terms with Torrubia and allowed him to examine the elder’s museum in Italy – was wrong to assert that there were matrices in the earth that were fed by a nutritive juice (Luzzini, “Matrices”). Torrubia denied that a petrifiying juice could act as a nutritive, or vegetative, juice that circulated internally and caused rock beds in the sea to grow into new mountains and rock quarries to replenish themselves (123-25).

Torrubia recurred to a different mechanism, that of *coagulation*. Successive layers of rock were added on from sedimentation and rock deposits, by dint of the water that carried molecules of matter across, through, and underneath rock (Torrubia 125). He termed this a “mechanical mode” (echoing De Baillou) and argued that water was the vehicle for the “material or seminal principle” (126). Water carried material particles, which bits were pulled by gravity into the pores of rocks and over time hardened until they became rock. That coagulation was not directed from within, however. There was no immanent seminal principle in stones, no seeds, no plastic virtue, no life. Bolstering Torrubia’s differentiation between the animate and the inanimate, was his friend, Fortunato Da Brescia, an Italian mathematician, natural philosopher, theologian, and anatomist who taught and lived in Spain for decades. As Torrubia was writing *Aparato*, Da Brescia’s textbook *Philosophia sensuum mechanica as usus academicos accomodata* (first published in 1735-36) was already in its third edition (1751-52). Da Brescia differentiated living and non-living things based on the origins of motion: inanimate objects were moved by external force because they did not have an immanent force that animated them as living things had (*Philosophia* 2: 324-25). As in the authors who preceded him, in Da Brescia there was a coalescence of mechanical physics and vitalist chemistry. Pierre Gassendi warranted Da Brescia’s affirmation that an active life force was the cause of locomotion in living things (Wolfe, “Role” 239; “Empiricist” 340). Willis, the Gassendist chemist and physician, supplied

Da Brescia with chemical explanations of vital force (Da Brescia, *Philosophia* 1: 191-92; O'Neal 130-31, 222-23, 227).

Da Brescia differentiated between two vital operations in the vegetable kingdom: nourishment (*nutritio*) and increase (*augmentatio*). Nutrition is an internal activity or taking from within (*intus susceptus*) that processes particles of matter and distributes them throughout living beings. Increase (*augmentatio*) is also called accretion (*accretio*), and it too is an internal motion (*intus susceptus*) in living things that ensures the proper organization so that they attain their specific dimension and magnitude. Hearkening back to the Later Scholastic authors, Da Brescia averred that non-vital growth depended on the apposition of matter. Vital growth depended on *intus susceptus*, and when it ended, life ended. Accretion (*accretio*) in the mineral kingdom did not have a temporal or spatial organization: the size of an inanimate body increased without plan or limit, and it entailed external surfaces rather than internal vital activity (*Philosophia* 4: 279-82).

In the following passage from Torrubia, I detect the vital-mechanist framework that he shared with Da Brescia and so many others:

> I have never discovered in any rock whatsoever (and I have observed a great many) a structure that might correspond (not even by the most remote Analogy) to the general laws of vegetation. I confess that rocks grow, but I have never discovered in any of them that combination of organs and mechanistic structures [*máquinas*], nor a single one of the mechanical parts that are suited and absolutely necessary for the economy of internal growth, like the ones found in old Holm oaks and in the hardest bones of all animals for the circulation of their juices. (Torrubia 130)

In Torrubia's rendering, God had endowed the natural world with mechanisms that operated on their own (they were truly mechanical), but not all mechanisms were organic. In plants, the particles carried by the nourishing juice made them grow and develop *per intus sumptionem* (122) through an organic mechanism. Human bone, no matter the postmortem crystallization of its interior as seen through his microscope, preserved the remains of once-vital activity. In the skull from Teruel, he observed traces of marrow, "a sign characteristic of a previous material nutrition that the juice which petrified it could not render" (Torrubia 50). Increase in rocks was "a mechanical mode" (126), as practice proved: "The Microscope makes us clearly understand this mechanism …" (129). There was no organized growth *in* rocks; their *non*-organic mechanism received the fluid particles of matter *from without*.

Unlike the agency of Bennett's vibrant matter, agency in pre-Romantic vital mechanics depended not only on the assemblage of matter, but also, and more importantly, on the larger assemblages of the universe as inscribed by human agency. Rocks, plants, and humans did not have identical agencies, because there was no internal organization of matter, no immanent mechanism, in rock to perform the vital functions of growth and development according to kind. True, the surfaces of stone were transformed without human agency, as in the mechanical processes of petrification that joined surface to surface. But the increase and "locomotion" of rocks was from without, and disordered, which spelled that it could never be agential.

Vitalism was and is context-dependent. The vital mechanics of matter that I have introduced here has been critically eclipsed by posterior developments in vitalism. It is a story that I cannot tell here, but I will point out that the semantics and conceptualization of the mechanical ordering of vital matter is the proverbial elephant in the room – always present and never acknowledged – for Bennett's framing of vibrant matter. Distinctions between organic and non-organic, no matter how radically they differed between the seventeenth century and the early-twentieth century, were always aligned with understandings of order and disorder. Secularized and rendered mysterious by poets, historians, and scientists, the *organisms* of early-twentieth-century vitalism might be summarized as clusters, or masses, of material bodies, awaiting their vital awakening and organization. Order was the hard core of vitalism's allure for Fascist and Nazi regimes.

Vital mechanics, as I have sketched it here, belonged to a different European theater. It confirms the heterogeneity and context-dependence of Enlightenment approaches to the life and material sciences that emerged in natural history, history, and natural philosophy around the mid-century mark. In this context, Pérez Magallón's *constructing modernity* is equally ontological and epistemological. It compels us to imagine alternative critical models for the history and philosophy of vitalism and materialism, such as the vital mechanics of matter. It shuttles us from teleological fallacies and abstractions to practices and objects in the external world – from theories, to the life of the particle.

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NOTE

1 Translations of Torrubia and other authors are my own, unless otherwise stated.

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