

## 5 Vibrant Matter in Practice

*One of the things that's fascinating about research into the world of the ultra-tiny is the way it changes the way you perceive every object around you. Instead of a table being solid, it's a bunch of molecules whose electrons are, as Schwartzberg put it, 'sloshing around.' Even an atom no longer feels like a solid thing. 'When you're looking at atoms, you're just measuring densities of electrons,' Schwartzberg said. Everything is fluid; everything is moving in particles and waves. (Newitz, 2013b)*

### 5.1 Overview

The cosmos is composed of many different species of stardust (Sagan, 2007) and despite our advanced, secular knowledge, we imagine these primordial substances give rise to a universe, fashioned in our own image, in which Nature and the technological expressions of the human mind, are cleaved. This chapter proposes that the material agency within vibrant matter is a real, physical phenomenon and ultimately a testable proposal, which is based on a new set of ideas about reality that paint a portrait of our universe. This is far more autonomous, lively and sensitive than the one that has historically framed western discourses that have relied on human reason for instruction. The lively character of vibrant matter is examined within this context and its agency attributed to real fundamental forces, grounded in quantum physics, rather than being the product of vitalistic theories (Bergson, 1922, p.44; Driesch, 1914, p.vi; Spuybroek, 2011; Bennett, 2010, pp.83–84), or psychological responses to material groupings (Bennett, 2010, p.4). My research seeks to empower matter by recognizing that its innate vitality resides within molecular bonds, which forge assemblages that can interact with and respond to their surroundings. Locating the liveliness of vibrant matter within the material realm provides the basis for an experimentally testable set of observations that may enable its better characterization and identify possible applications in architectural design.

### 5.2 The Dynamic Nature of Matter

All matter squirms. This is the fundamental reality that underpins our cosmic fabric<sup>34</sup> (see Fig. 5.1).

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<sup>34</sup> This NASA simulation of galaxy formation during the first two billion years of the universe (YouTube, 2013) illustrates the dynamic character of Millennial Nature.



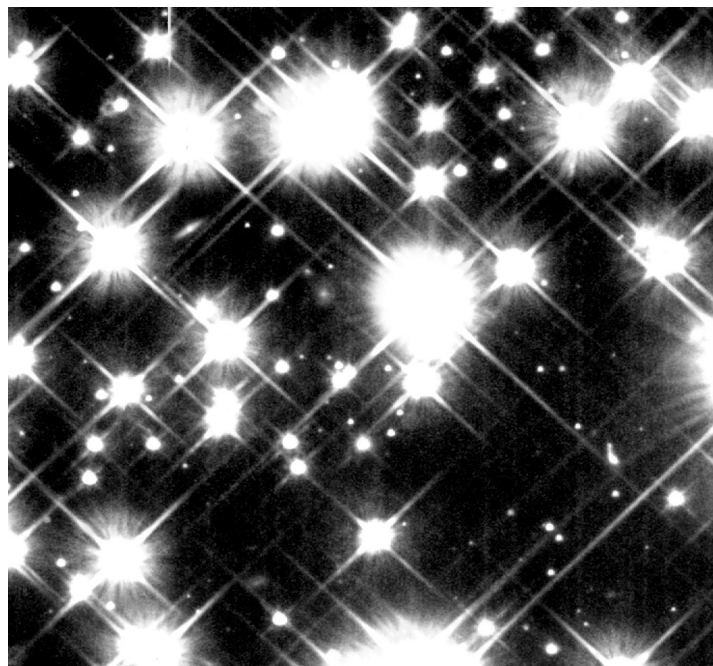
**Figure 5.1:** This spiral galaxy is a rotating disk of stars, gas and dust that gives rise to about 60% of our local universe. Photograph, courtesy Space Telescope Science Institute (STSci).

During the Enlightenment, when Galileo and Newton set out the mathematical principles of the universe as ‘natural laws’ (Kauffman, 2008, p.xi), ideas that shaped our world as an expression of brute materiality that required rational instruction were forged. Rene Descartes compounded these notions by severing our experience of the world into encounters between an ephemeral substance (soul/mind) and mechanical body (Descartes, 1983). Classical science therefore developed the habit of describing matter in passive terms, which was infused by an active agency whose physical substance could be completely contained within and defined as an expression of geometry. Yet there is nothing simple about matter. Material forces and flows are not best imagined as deterministic systems, since they are reactive and capable of transformation. For example, when two gases, hydrogen and oxygen, are combined they produce liquid water. Material vigour does not originate from a geometric understanding of materials, nor their essential qualities, but through molecular processes that forge their interactions from which novelty emerges.<sup>35</sup> While the atomic

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<sup>35</sup> In *Intensive Science and Virtual Philosophy*, DeLanda argues that Deleuze’s concept of multiplicities is designed to replace the old philosophical concepts of essences, and that things, substances, or objects are to be explained in terms of how they are produced, rather than in terms of their essence. As

model proposes that matter might be reduced to fundamental units, called atoms, modern science has theoretically and experimentally demonstrated that these are not simply irreducible objects, or particles (see Fig. 5.2).



**Figure 5.2:** These white dwarf stars are composed of electron-degenerate matter and are thought to be the end stage of 97% of all stars in the Milky Way. Photograph, courtesy Space Telescope Science Institute (STSci).

At the subatomic level matter is more complex and exists as probabilistic clouds of muons, leptons and hadrons that behave as waves and particles (Bitbol, 1996; Lederman and Teresi, 1993, p.168). David Bohm suggested that atoms act as amplifiers of information contained in quantum waves (Bohm, 1973), which are connected within a universal network of subatomic particles called the ‘Implicate Order’ (Bohm, 1980), and within this cosmic fabric, atoms do not always appear to obey Newton’s laws. Quantum physics therefore uses an alternative conceptual framework to understand these new characteristics and raises challenging epistemological issues about

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DeLanda puts it, ‘[i]n a Deleuzian ontology [...] a species (or any other natural kind) is not defined by its essential traits but rather by the morphogenetic process that gave rise to it’ (DeLanda, 2002, p.10).

materiality, such as in the Heisenberg Uncertainty Principle, which proposes that matter is deeply entangled with our measurement and observation of it (Heisenberg, 1927, pp.62–84). Although particle physics might be dismissed as being relevant only to very small scales of operation, the Correspondence Principle asserts that conflicting micro and macro realities cannot coexist (Nielsen, 1976). Yet, John Haldane observed the importance of the size of an object, institution or animal in establishing their structure, as molecular relationships need to strengthen more than proportionately as the size of systems increased if the structures were to remain robust and resilient (Haldane, 1926). So, if matter possesses fundamental liveliness, then this should be discernable at the macroscale and not just at the level of particles and atoms. Indeed, quantum phenomena shape our experience of the world, which we perceive as fundamental properties of matter, such as colour and the effects of gravity. However, the modern world wrestles with polarities of being, where natural events can be imagined and explained as the product of dualistic forms of existence and geometric functions, whose ordering can be manipulated through binary representations using digital computing methods. Indeed, dualism is contained within the very language and codes we think with and even embody our ideas about ‘life’ (Armstrong, 2009b).

Recently, Markus Covert compiled data from more than 900 scientific papers to account for every molecular interaction that takes place in the life cycle of *Mycoplasma genitalium* – the world’s smallest free-living bacterium – to create a digital model of how it works (*Stanford News*, 2012). The digitalization of living systems into a binary sea of zeroes and ones is encapsulated by J.C. Venter’s team building an artificial genetic code using a form of biological computing called ‘systems genomics’. This incredible feat of engineering produced ‘Synthia’, an organism which was extracted from its binary soup and animated in a ‘ghost’ yeast body to become the world’s most ambitiously manufactured synthetic organism (Gibson, 2010). Both Synthia and Covert’s organizational topology embody an Enlightenment view of matter, which is inert, insensitive to its environment and requires external instruction to perform tasks. It springs from a mechanical worldview where brute matter can be built from identified parts and infused with ephemeral instructions encoded in digital or analogue information streams. They are subsequently transformed into a lively configuration that is assembled atom by atom. Attempts to vitalize this base image of matter, such as Hans Driesch’s view of ‘entelechy’<sup>36</sup> or Henri Bergson’s ‘vital’ principle (Bergson, 1922, p.44), only reinforce the idea of a material world in which agency is an afterthought. As Latour notes, ‘to be both material and social’<sup>37</sup> is not a way for objects

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<sup>36</sup> Aristotle’s entelechy is neither material nor spatial, and manifests its action by a diversity of operations of the organism. Hans Driesch describes it as ‘intensive manifoldness, which orders each part to the whole and gives to the organism its reality as a living being. It is the principle of life, the ordering “form” of the living body. Finally, it acts as the final cause’ (Driesch, 1929, pp.1–113).

<sup>37</sup> Here, the reader may substitute terms that imply other intangible agencies, such as mental, vital, language, etc., for the term ‘social’ in this quote, which is Latour’s particular subject of interest.

to exist: it is simply a way for them to be artificially cut off and to have their specific agency rendered utterly mysterious' (Latour, 2005, p.83).

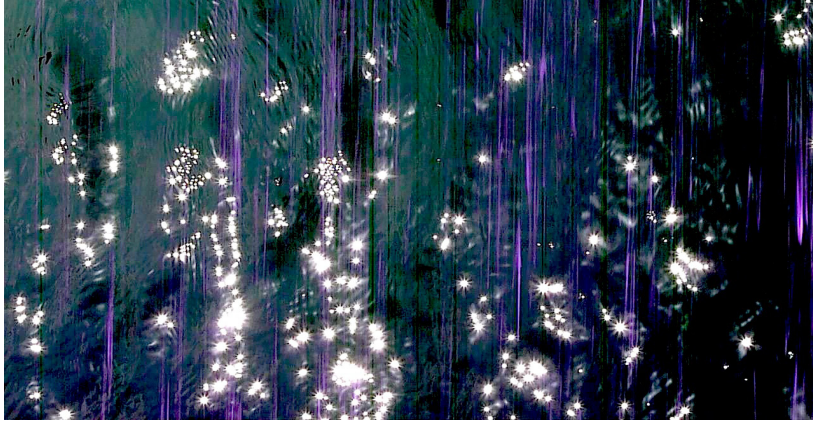
Researchers such as Vladimir Vernadsky (Vernadsky, 1945; Vernadsky, 1998; Vernadsky, 2007), Ilya Prigogine (Prigogine and Stengers, 1984), and Stuart Kauffman (Edge, 2008) reject the brute nature of matter by observing the world through another scientific lens described by Ludwig von Bertalanffy as 'general systems theory' (Von Bertalanffy, 1950), more commonly encountered as 'complexity'. This breaks away from the geometric discourses of the Galilean Spell (Kauffman, 2008, pp.129–149) by considering reality as a network of relationships and flows, which are never fixed and always under construction. Latour identifies actants (Latour, 2005, p.54; Bennett, 2010, p.9), not atoms, as the fundamental organizing agents within the complex worldview of ANT. This challenges the anthropocentric assumptions at the heart of western philosophy by drawing attention to the subversive agency within non-human bodies (Latour, 1996). Actants are considered from a materialist perspective as probabilistic clouds of action that are both objects and processes, which work through groups of interassociating bodies, or assemblages. Since the individual influence of actants is weak, their phenomenological, social, cultural and even political power is a consequence of their group activity. The effects of actants are not constrained by the geometric limits of their materials but they exert their effect by building real relationships that define their field of activity through a spectrum of types and strengths of molecular interactions. Actants therefore operate through the production of assemblages at different scales and exert varying degrees of influence on their surroundings, such as light at an air/water surface (see Fig. 5.3). Their influence not only draws from Newtonian laws of cause and effect but also embrace counter-intuitive, strange behaviours such as quantum entanglement.<sup>38</sup> Actants may therefore coherently inhabit both complex and classical scientific frameworks and may be observed as objects and as systems.

Yet our cultural conditioning in observing the world around us as one thing or another, leaves us habitually trying to resolve apparent contradictions. In fact, as in the case of photons, these paradoxes are an intrinsic to the fabric of reality. While architectural design has consciously appreciated the centrality of objects according to the classical scientific model, it has not developed formal strategies for designing with the potentially stranger role of materials as process. Identifying the materials, infrastructures, technologies and expectations of matter as process could help catalyse shifts in the performance and expectations of buildings. Yet the diversity and abundance of its processes, which are expressed through 'metabolism', characterize the natural world. Even the grand objects placed in the urban landscape that constitute contemporary architecture are swathed in organic seas of microsystems that inhabit

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<sup>38</sup> Albert Einstein called quantum entanglement – two particles in different locations, even on other sides of the universe, influencing each other – 'spooky action at a distance' (Science Daily, 2013).





**Figure 5.3:** The dynamic nature of matter is clearly visible at the interface between water and light. This theme of interface, such as air/water or oil/water, as a site for transformation is a recurrent theme in my research. Photograph, Rachel Armstrong, August 2012.

their inert edifices like plaque. These relentless assemblages work tirelessly to corrode, transform and decompose even our most resilient buildings and remind us that we inhabit a dynamic, microbial world. Earth's micro-communities have given rise to our ancestry over billions of years, having produced the soils and the atmosphere that we breathe (Su et al, 2011; Royal Society of Chemistry, 2011). However, architectural conventions, with their calibration systems set at the human scale, not only overlook the importance of our micro-ecologies but also ignore the largest portion of Earth's natural living history in which humans are an extremely late arrival. We are entangled within a non-human reality, whose living and non-living actants, when considered en masse, prove to be a lively force to be reckoned with.

Vibrant matter becomes creative and convincing as a real phenomenon when it is actively forging assemblages through the persistent material interactions that enable heterogeneous groups of actants to horizontally couple together and produce potentially surprising outcomes (see Fig. 5.4).

These restless networks of molecular interactions are not simply a mass of wriggling, indeterminate forces that render a designer's task as futile as nailing jelly to a wall – they possess a structural quality, which is forged by organizing hubs that create linkages between and within the open relations of matter. For example, haematite crystals appear to undergo lifelike cycles of growth and decay in response to chemical gradients and blue light, which are quenched when the lights go out (Palacci et al, 2013). Materials that are at far from equilibrium states may be uncannily lifelike, with striking characteristics such as movement, innate intelligence, environmental sensitivity and change with the passage of time. 'Living' systems possess some of the



**Figure 5.4:** Simple chemical systems, such as Bütschli droplets, may exert effects on their surroundings. Micrographs and collage, magnification 4×, Rachel Armstrong, February 2010.

qualities of fully alive agents, such as growth, movement or sensitivity, but may have not been given the full status of ‘life’. Yet they share the same chemical language as the biological world so that, as Richard Lewontin observes, organisms and their environments ultimately ‘co-evolve’ (Moran, 2008). Indeed, Vernadsky argued that no living organism exists in a free state on Earth and proposed a conception of Nature that combined geochemistry and biogeochemistry, which embraced both non-living and living systems that continuously connected them to the biosphere through processes such as feeding and breathing (Vernadsky, 1945).

Although minerals are more limited in their capacity to generate change by forming new compounds or forging assemblages when compared with biotic materials, they still offer a portfolio of choices from which Charles Darwin’s notion of Natural Selection may operate (Darwin, 1999) and may even possess an innate evolvability (University of Central Florida, 2013). The mineral world has a structural memory that can be observed through the behaviour of metal alloys (Phys.org, 2010), or the production of crystals (Nobelprize.org, 2013) and compounds, which also have the capacity to shape events and possess technological potential. Stéphane Leduc (Leduc, 1911), who coined the term ‘synthetic biology’, used a variety of mineral systems to demonstrate their lifelike character, and A.G. Cairns-Smith proposed an even more

intimate connection between the mineral domain and living matter by proposing that the first life forms originated from clay minerals (Cairns-Smith, 1971).

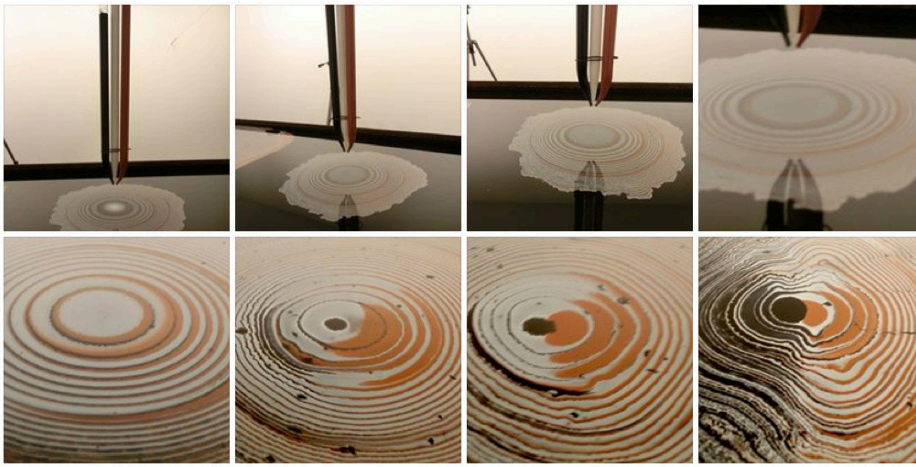
Contemporary research has confirmed that clays, such as montmorillonite, may have been key to biogenesis (Hanczyc, Fujikawa and Szostak, 2003), while William Bryant Logan regards ‘the clay code’ as being ‘more complex than either the genetic code or human language’ (Logan, 2007, p.127). Minerals have contributed significantly to setting the conditions for life to flourish and continue to do so. The role of iron pyrites in removing sulphur from the ocean and producing atmospheric oxygen has recently been established as being much more important than was previously thought (Weizmann Institute of Science News, 2012). The shared ontology of matter that Bennett takes such care to establish is written into the history of life on Earth, where living and non-living systems have persistently worked to enrich chemical networks through countless environmental acts that are enjoined in the process of evolution. Perhaps ‘evolution’ is not a single event but infinite, incessant, co-evolutionary, collaborative acts of material exchange with the biosphere, whose collective effects are recognized by human observers at a single moment in time (Gould, 1994).

With the awareness that our environment is unstable, with no divine obligation to support us, we are experiencing a cultural change away from the Enlightenment ideals in the way we imagine the ordering of the world. We live in a world of definable probability that is physically entangled in networks of continuous exchange in which life and matter incessantly evolve – and designers are beginning to construct new ways of dealing with this ambiguous state of affairs. For example, Xandra van der Eijk works with decay, using a device that enabled her to develop a self-painting apparatus that is active during 4–6 day cycles (Meta.morf, 2012a) (see Fig. 5.5).

The prints that van der Eijk lifts off the water surface speak of an archaeology of process that captures forms of self-organization, which mark our own decay towards entropic equilibrium. Indeed, boundaries that were once consolidated by duality – machine/human, man/woman, and organic/inorganic – are now incontrovertibly blurred, and links between different worlds – such as quantum and macroscale realities – can even be mapped as these borders are breached (Nimmrichter and Hornberger, 2013). Increasingly, these ideas are becoming culturally adopted, such as through Henri Lefebvre’s *Rhythmanalysis* (Lefebvre, 2004), which embodies aspects of the Implicate Order.

Yet the precedents for recognizing material agency draw from encounters with Nature where natural processes reveal deep truths about the potential for construction that lies within the materials and elements that form the world in which we are immersed (Ruskin, 1989). While mountains such as the Matterhorn take hundreds of thousands of years to be ground down by the elements, other formations are more evanescent. For example, ‘ice-flowers’, which are bacterially rich, strange structures, grow under the most particular conditions during the polar winter and then disappear again as quickly as they formed, leaving no trace of their existence





**Figure 5.5:** Van der Eijk's automatic drawing system harnesses the flow of paint and water to produce a self-evolving pigment series that is recorded through time-based prints. Photograph collage, Rachel Armstrong, September 2012.

– like a polar microbial Brigadoon.<sup>39</sup> They are composed from frozen atmospheric moisture and brine drawn through capillary action from the surface of the sea ice, which concentrates salt and bacteria from the sea (Dias, 2012).

Self-assembling processes can also be precipitated under controlled conditions, in gallery settings. Architect Tetsuo Kondo has used cloud technology to experiment with new types of spatial effects for the Tokyo Museum of Contemporary Art (Quay, 2013) where visitors can climb the stairs in a transparent room above the interior cloud; while Dutch artist Berndnaut Smilde (Design Boom, 2012) created an eerie and whimsical illusion of a cloud floating within a gallery space, which was produced using smoke, moisture and backlighting. This ephemeral formation often lasted only for a moment before it dissipated entirely. Indeed, material assemblages offer a new kind of technological platform, with an intriguing portfolio of opportunities that collaborate with designers in codesigned acts of creativity.

### 5.3 Summary

The magic of our reality is not that absolutely anything is possible, but that there is a great deal of untapped potential that already exists within the material world, as a real, not imaginary, phenomenon. By framing our understanding of matter so

<sup>39</sup> Brigadoon is a mythological village, a magical structure, which only appears every hundred years (YouTube, 2008).

that it is in keeping with the extraordinary insights and developments that we have gained throughout the 20th century, we may be able to get a whole lot more from it. But we will not achieve new paradigms in architectural design practice by treating the material world as being full of inert things to be controlled or consumed by machines, but by liberating its innate potential and co-evolving our living spaces in partnership with vibrant matter – which promises to be a conservative force with revolutionary potential.