



Iconoclasm and Imagination: Gaston Bachelard's Philosophy of Technoscience

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Published online: 13 November 2019
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Abstract

Gaston Bachelard (1884–1962) occupies a unique position in the history of European thinking. As a philosopher of science, he developed a profound interest in genres of the imagination, notably poetry and novels. While emphatically acknowledging the strength, precision and reliability of scientific knowledge compared to every-day experience, he saw literary phantasies as important supplementary sources of insight. Although he significantly influenced authors such as Lacan, Althusser, Foucault and others, while some of his key concepts (“epistemological rupture,” “epistemological obstacle,” “technoscience”) are still widely used, his oeuvre tends to be overlooked. And yet, as I will argue, Bachelard’s extended series of books opens up an intriguing perspective on contemporary science. First, I will point to a remarkable duality that runs through Bachelard’s oeuvre. His philosophy of science consists of two sub-oeuvres: a psychoanalysis of technoscience, complemented by a poetics of elementary imagination. I will point out how these two branches deal with complementary themes: technoscientific artefacts and literary fictions, two realms of human experience separated by an epistemological rupture. Whereas Bachelard’s work initially entails a panegyric in praise of scientific practice, he becomes increasingly intrigued by the imaginary and its basic images (“archetypes”), such as the Mother Earth archetype.

Keywords Gaston Bachelard · Philosophy of science · Science and literature · Psychoanalysis of science · Imagination · Epistemological rupture · Archetypes

Introduction

Gaston Bachelard (1884–1962) occupies a unique position in the history of European thinking. As a philosopher of science, he developed a profound interest in genres of the imagination, notably poetry and novels. While emphatically

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acknowledging the strength, precision, productivity and reliability of scientific knowledge compared to every-day experience, he saw literary phantasies as important supplementary sources of insight. Although he significantly stimulated authors such as Jacques Lacan, Louis Althusser and Michel Foucault, while concepts such as “epistemological rupture,” “epistemological obstacle” and “technoscience” are still widely used, his oeuvre tends to be overlooked in mainstream science studies discourse. And yet, Bachelard’s prolific series of books opens up an intriguing perspective on contemporary scientific research practices. Moreover, after being criticised and discarded by prominent voices such as Michel Serres (Serres and Latour 1995), Stengers (1993/2000) and Latour (1993) (see Rheinberger 2005; Kotowicz 2018; Simons 2019), we currently witness a revival of interest, a reappraisal of his work (Pravica 2015; Smith 2016; Kotowicz 2018; Bontems 2018, 2019),—and for good reasons, I will argue.

The composition of this paper is as follows. First, I will explore a basic duality that runs through Bachelard’s oeuvre. His philosophy of science actually consists of two sub-oeuvres: a *psychoanalysis of technoscience*, complemented by a *poetics of elementary imagination*. Subsequently, I will point out how these two branches address complementary realms of human experience: *technoscientific artefacts* and *literary fictions* respectively, separated from one another by an *epistemological rupture*. Whereas Bachelard’s work initially entails a panegyric of scientific research, he becomes increasingly intrigued by (or infected by) *the imaginary* and its basic images (“archetypes”), such as the *Mother Earth archetype*.

Science and Imagination: Bachelard’s Two Oeuvres

A remarkable ambivalence runs through Bachelard’s work. On the one hand, he firmly supports the way in which modern science (or “technoscience”) fosters the quantification and symbolisation of the real, replacing everyday experiences by measurements, mathematical and chemical symbols, equations, and the like. An *epistemological rupture* (Bachelard 1938a/1970) separates technoscience from the immediacy of every-day life-world experience, which remains under the sway of the imaginary (e.g., imaginative, pre-scientific worldviews). On the other hand, in a complementary series of books, Bachelard scrutinizes the imaginative style of thinking fleshed out by genres of the imagination (e.g., novels and poetry).

Thus, Bachelard’s philosophy of science splits into two branches: a philosophy of technoscience, focussed on how science reveals the noumenal dimension of the Real via chemical formula and mathematical equations (Bachelard 1931/1932), supplemented by a phenomenological poetics of literary imagination. This split (*Spaltung*) results in a divided oeuvre, so that Bachelard was the author of two completely different types of books, written in a different style. In one and the same year (1940a), for instance, he published both *The Philosophy of No* (1940b/1949, a polemical defence of technoscientific rationality) and a study of

the poetic imagery of Lautréamont, a precursor of surrealism (1940a). The contrast between these two subgenres, in terms of content and style, is quite remarkable (Bontems 2019: 21). And yet, a “hidden unity” (Lecourt 1974: 32: 139) joins these opposites together.

The bond between technoscience and imagination is provided by psychoanalysis as an overarching frame. Bachelard's philosophy first of all consists of a psychoanalysis of the technoscientific ego: the subject of science, whose intentionality is focussed on very specific objects of research. This psychoanalysis of technoscientific *consciousness* is complemented, however, by a depth psychology of the *unconscious* of science: the subliminal images that continue to emerge in the context of experimental laboratory research. This requires *a different stage*, a different *Schauplatz*, as Freud once phrased it (1900/1942: 541), which, according to Bachelard, is provided by literature (in the sense of belles-lettres). Poetry and novels are to science what dreams and day-dreaming (*reverie*) are to critical consciousness (the ego and super-ego at work in scientific research). They serve as windows providing access to the unconscious realms of laboratory life. What remains subliminal in science, becomes manifest in literature (see Freud's famous dictum *acheronta movebo*: if a straightforward analysis of consciousness proves insufficient, try a detour via the nether realms of psychic existence; Freud 1900/1942). Bachelard focusses on the *elementary* imagination, moreover: on images and phantasies associated with the ancient elements (earth, water, air and fire). Whereas in scientific discourse these images have been discarded and replaced by the periodic table of elements, they continue to thrive in genres of the imagination.

This divide between subgenres results in two parallel series of publications, as indicated below:

Bachelard's ergography (overview of key publications)

Philosophy of technoscience	Poetics of elementary imagination
1932 Noumène et microphysique	
1932 L'Intuition de l'instant	
1934 Le nouvel esprit scientifique	
1936	La dialectique de la durée
1938 La formation de l'esprit scientifique : contribution à une psychanalyse de la connaissance objective	La psychanalyse du feu
1940 La philosophie du non : essai d'une nouvel esprit scientifique	Lautréamont
1942	L'eau et les rêves
1943	L'air et les songes
1946	La terre et les rêveries du repos
1948	La terre et les rêveries de la volonté
1949 Le rationalisme appliqué	
1951 L'activité rationaliste de la physique contemporaine	
1953 Le matérialisme rationnel	
1958	La poétique de l'espace
1960	La poétique de la rêverie

Furthermore, both in his psychoanalysis of technoscience (left column) and in his poetics of the imagination (right column), two dimensions can, again, be discerned: a phenomenal and a noumenal dimension. In both cases, the phenomenal dimension concerns immediate observations, although the phenomena studied by technoscience differ significantly from the phenomena that are captured by literary genres. Eventually, however, the objective of both is to move beyond immediate impressions and to reveal the noumenal dimension: the basic, elementary structures (1931/1932; see Bontems 2019: 22). This first of all applies to technoscience. Scientific phenomena, Bachelard argues, are laboratory artefacts: phenomena produced, modified and analysed with the help of high-precision equipment (laboratory contrivances). The intentionality of technoscience is focussed on processes or entities (e.g., chemical reactions, model organisms, etc.) which only exist in laboratory settings (in vitro). Therefore, technoscientific research practices consist in producing and analysing technoscientific phenomena, so that technoscience is basically a *phénoménotechnique* (Bachelard 1934/1973: 17). Scientific theories are validated not through verification, but through technological *realisation* (Wulz 2010: 17 ff.). Technoscientific research fields such as molecular biology or quantum physics disclose the *noumenal* dimension of nature with the help of mathematical and chemical symbols and equations, amounting to a “symbolisation” of the Real, systematically replacing tangible, visible entities by scientific formula.

Something similar, however, is discernible in the imaginary realm as well. The poetics of imagination starts off as a systematic phenomenology of literary images, but Bachelard’s depth psychology eventually aims to reveal that human imagination is pre-formatted by a limited set of guiding images or archetypes. An archetype is an a priori form (εἶδος) which *realises* itself in a certain context (e.g., the Mother Earth archetype resurging in Jules Verne’s *Journey to the Centre of the Earth*, a novel about geography, or, to use a more recent example, the monster archetype resurging in Michael Crichton’s *Jurassic Park*, a novel about palaeontology). As a psychoanalyst of technoscience, Bachelard’s research is bent on revealing the unconscious obstacles (archetypal images, projections and associations) that are barring scientific progress. This requires an extensive depth psychology of archetypes:

Bachelard’s ergography (condensed version).

	<i>Phenomena</i>	<i>Noumenal structures</i>
<i>Psychoanalysis of technoscience</i>	Technoscience as “phénoménotechnique”	Science as a symbolisation of the noumenal dimension of the real
<i>Poetics of elementary imagination (earth, water, air, fire)</i>	Phenomenology of literary reveries	Archetypes as a priori structures or templates of the imagination

Bachelard’s psychoanalysis of technoscience has *practical* implications. It aims to support the formation (*Bildung*, training) of future researchers (Bachelard 1938b/1970) by explaining what technoscience is, focussing on the technicity of

scientific research. An epistemological rupture separates the logic of technoscience from experiential existence in the every-day life-world, and scientists should actively *emancipate* themselves from pre-scientific, imaginative world-views, which remain under the sway of archetypes. As a psychoanalysis of technoscience, Bachelard's work intends to aid scientists in their emancipatory struggle, their epistemological conversion. By confronting scientists with literary amplifications of archetypal images in poetry and novels, they will become more aware of them, so that they may recognise them in their research practices, and come to terms with them, and deal with them. Bachelard especially focusses on the *elementary* archetypes, associated with the ancient elements. It is here that the scientific unconscious can most likely be encountered. Therefore, Bachelard's "noumenology" of technoscience is complemented by a meta-poetics of archetypal images, in literary documents, but also in technoscientific discourse as such.

Gradually, however, Bachelard became increasingly fascinated (infected) by the archetypal structures he encountered, emphasising that they play a positive role as well. Eventually, he even stresses the extent to which the iconoclastic scientific style of thinking (the "cold violence of reason," with its "scissors of censorship," 1940a: 91) may *deform* our perceptivity (1942/1947: 80). Bachelard's oeuvre *as such* reflects a return of the repressed insofar as the psychoanalysis of technoscience is complemented by a meta-poetics of elementary imagination.

The epistemological rupture is also a historical one. A similar divide (between technoscience and reverie, between symbolisation and imagination) constitutes the historical transition between alchemy and modern natural science. In alchemy, the basic archetypes can be encountered that still flourish in modern literature. Modern science is the result of a repression: a systematic elimination of archetypal material from scientific discourse, but the archetypal (alchemistic) images that are systematically expelled from science tend to resurge in poetry and novels. Moreover, these archetypal elements are never completely erased once and for all. They continue to be at work in science, albeit in subliminal ways, and Bachelard's vocation as a psychoanalyst is to reveal their hidden presence. Catharsis (epistemological cleansing) proves an interminable endeavour. What is subliminally present in scientific discourse, but often remains unsaid and unseen, can be detected more easily by studying literary counterparts.

In contemporary academic discourse, Bachelard is much better known for his poetics (especially of space: Bachelard 1957) than for his psychoanalysis of technoscience, but these two sub-oeuvres belong together. Initially, Bachelard saw rational concepts and archetypal images as opposites and wanted to "exorcise" archetypal associations from technoscientific discourse (1960: 45). Eventually, however, he realised that both poles (the rational and the imaginative, the symbolic and the imaginary) go together as interpenetrating opposites, as complementary dimensions that must be alternately addressed (Bachelard 1960: 47). Contrary to classical (Freudian) psychoanalysis, moreover, Bachelard's aim is not to psychoanalyse individual authors. His intentionality is focussed on science as a collective discourse, to which a large number of authors contribute, both major and minor ones (1960: 3).

So far, we focussed on the *subject pole* of the knowledge relationship, indicating how scientists are divided subjects, trapped between the demands of technoscientific

methodologies and the intrusions of the imaginary. In the next section the focus shifts to the *object pole* of the knowledge relationship: the facts and fictions actually produced by technoscience and literary imagination respectively.

Scientific Artefacts and Literary Fictions

In *Dawn of Day*, Friedrich Nietzsche (1881/1980, § 307) summarises his view on scientific research in an exclamation (*Facta! Yes Facta Ficta!*) which plays on alliteration to highlight an intriguing etymological connection between *fact* and *fiction*, terms which are usually seen as opposites. While *fact* is derived from the Latin verb *facere* (to fabricate), *fiction* comes from the Latin verb *fingere* (literally: to bring forth with one's fingers). Etymology emphasises that both facts and fictions are *made, produced*, rather than given, and this notably applies to scientific facts. They are products of technoscience, of laboratory research; they are (literally speaking) *fabrications, artefacts*: outcomes of sophisticated research practices, fabricated with the help of special research contrivances. Nietzsche's alliteration reminds us that scientific facts are "fingered" by the scientific method (Zwart 2019b).¹

When a scientist discerns a research object for the very first time (e.g., when Van Leeuwenhoek for the first time spotted spermatozoa through his microscope), such observations are not yet scientific, Bachelard argues (1957: 147). Primal scenes are vulnerable for imaginary associations (for instance when researchers allegedly detect preformed miniature versions of human beings inside sperm cells). It is through repetition, replication, verification and standardisation that impromptu sightings become scientific observations. Science (the experimental spirit) must *transcend* immediate observation, referred to by Hegel as the *beobachtende Vernunft* (see Pravica 2015: 27). In order for scientific facts to be credible and convincing, recipients must trust the way in which technoscientific knowledge is produced. When Galileo tried to persuade contemporaries to study the Moon with the help of a telescope instead of with the naked eye, the question was whether telescopes could be trusted, for although they provide a more precise and detailed view of the Moon's bleak surface (pummelled by meteorites), beholders inevitably lose sight of the firmament as a whole. Technoscientific contrivances result in the death of holism. There is something artificial about scientific facts, even though they are generated in a methodical and replicable way.

The relationship between facts and fiction is a key issue in Bachelard's work. For him, science is not about *knowing the facts*, but about *knowing how* they are produced. Before the dawn of modern science, human thinking was highly imaginative, resulting in fascinating, seductive worldviews, based on imagination and projections, on "intuitive metaphysics" (1934/1973). An epistemological rupture divides modern scientific research (conducted in artificial settings known as laboratories)

¹ A similar etymology can be discerned in the word *laboratory*, which builds on the Latin verb *laborare* and literally means "workshop": a locality where certain entities are manipulated (literally: *handled*) and certain products (namely facts) are fashioned or moulded (in a hands-on, fingering way).

from mundane life-world experiences. A laboratory object, Bachelard argues, is an artefact (a model organism, a particular molecule, a purified sample of a chemical substance, etc.), produced and maintained with the help of laboratory equipment (*in vitro*), often unable to exist or survive in the outside world. Paradoxically, laboratories (although designed to study nature) are secluded places where real (outdoors) nature is kept at bay and only small samples of reality (controlled and manipulated by scientific dexterity and laboratory equipment) are allowed to enter. Rather than studying phenomena as they present themselves to us, scientists design contrivances that allow them to measure and manipulate these phenomena as effectively as possible (so that knowledge equals power and vice versa). In other words, what scientists are studying (under controlled conditions) are laboratory entities. While pre-scientific worldviews rely to a large extent on imagination and projection, science relies on manipulation and quantification. Science is *iconoclastic*, rather than imaginative (Bachelard 1938a/1970: 38: 77). Tenacious images must be destroyed in order to disclose the neo-objects of science (1940b: 149). And whereas phenomenology analyses phenomena emerging in the every-day life-world, laboratory research entails a “phénoménotechnique” (1934/1973: 17, 1938b/1970: 61, 1949/1962: 3). Science is a technological experimental practice and scientific phenomena are technical phenomena, brought about by instruments that produce drastic simplifications of physical nature (1934/1973).

Bachelard consistently emphasises the technical aspect of science, seeing technology as constitutive of the scientific *modus operandi* (Rheinberger 2005). Scientific objects are materialisations of the scientific style of thinking, allowing scientists to produce, control and replicate artificial facts.² Instead of adequately reflecting the world, what is brought about by science (i.e., objectivity) reflects the principles of scientific rationality itself. Every-day reality is replaced by a technical neo-world (1940b/1949: 33). For Bachelard, the intentionality of traditional phenomenology is too passive and intellectual (Kotowicz 2018: 55). The intentionality of scientific experimentation is much more transformative and focussed, giving rise to phenomena and substances (such as transuranian elements or genetically modified organisms) which go beyond what can actually be found in nature, giving rise to a “factory of phenomena” (Kotowicz 2018: 57). The “surrealism” of science (e.g., of quantum physics, with its sub-atomic “sub-objects,” Kotowicz 2018: 139) is the scientific counterpart of surrealism in the imaginative realm (Kotowicz 2018: 39, 138). Both transcend every-day reality to disclose an unknown realm of weird events and entities, of “sur-objects” such as the atom (see Alunni 2015; Smith 2016: 43; Bontems 2018: 8; Simons 2019: 63).

Eventually, Bachelard argues, it is not the phenomenal (empirical), but the noumenal dimension of nature that scientists are after. Rather than studying water as we know it from every-day experience (water as a concrete phenomenon with a particular colour and taste for instance), scientists study H₂O, a chemical formula which captures water’s noumenal structure (1932/1970: 19, 1940a/1949: 60, 1951:

² “Il faut que le phénomène soit trié, filtré, épuré, coulé dans le moule des instruments... Les instruments ne sont que des théories matérialisées. Il en sort des phénomènes qui portent de toutes parts la marque théorique” (Bachelard 1934/1973: 16).

15): that what water essentially is. Science transcends reality as given to open up the noumenal realm of micro-objects and micro-phenomena, of molecules and atoms (Pravica 2015). For Bachelard, epistemology of science is “micro-epistemology,” focussing on the molecular, noumenal level, inaccessible for the natural senses, brought to the fore by scientific technology, by technoscience.³ For Bachelard, the noumenal is no longer a negative term (indicating an unsurpassable boundary), but sublated into something positive, accessible through scientific experimentation and advanced mathematics (Pravica 2015: 47).

All objects are bi-objects, composed of a phenomenal and a noumenal dimension, and scientific progress consists in progressively revealing the latter (see Pravica 2015: 48). This duality is reflected in Bachelard’s own research as well, as we have seen, where a *phenomenology* of the every-day lifeworld is explored through a systematic analysis of guiding images, while technoscientific observations become explainable and predictable on the basis of a scientific *noumenology* (Bachelard 1951: 80; see Kotowicz 2018: 55). In scientific discourse, visible, tangible phenomena disappear from view. They become obliterated by tools and methodologies thematised as “phenomenotechnique,” bent on revealing the noumenal dimension (on the molecular composition of matter). The vocation of philosophy, as Bachelard sees it, is not to produce a priori knowledge about nature (via metaphysical contemplations), but to critically reflect on knowledge forms produced by specialised research fields (Chimisso 2001: 65; Pravica 2015: 30: 36; Smith 2016: 24). Studying science from a close distance allows philosophers to develop an epistemology that is non-Kantian (similar to how modern mathematics became non-Euclidian, Simons 2019), allowing philosophy to drastically revise its basic categories. The problem is that philosophers often fail to keep pace with what is happening in science, so that a process of catching up is indicated, to become more aware of the vicissitudes of “subjects” and “objects” of research, not as metaphysical conceptions, but as real-life entities existing in laboratories.

Science as a Formative and Transformative Praxis

While the *objects* of science are laboratory artefacts (rather than natural entities), the *subjects* of science, i.e., the researchers themselves, are reformed and remoulded as well, via systematic scientific training, a formative process which amounts to a spiritual “reformation” (Bachelard 1938a/1970: 23). The subject-object relationship is a dialectical dialogue which transforms both poles. Scientific objectivity is a transformed reality which bears a human mark (Chimisso 2001: 92), but researchers themselves are likewise subjected to a permanent and auto-polemical process of “self-surveillance” (Bachelard 1949/1962: 7) or “auto-psychoanalysis” (Bachelard

³ And this now also applies to, for instance, archaeology, where facts are nowadays produced with the help of technologies such as radiocarbon dating or DNA sequencing of organic remains. Current archaeology would be unthinkable without bio-chemistry, genome sequencing and computers (Jones 2001; Pääbo 2015).

1949/1962: 14). Psychoanalysis is necessary because, even in modern culture, the power of the imaginary remains “pervasive” (Chimisso 2001: 2). Self-surveillance by an epistemological super-ego: i.e., the scientific method, brings about an “epistemological rupture” (Bachelard 1938b/1970), a “conversion” (Bachelard 1940b/1949: 8) as a result of sustained laboratory labour (Bachelard 1938b/1970: 50), allowing (or forcing) researchers to break away from the sway of pre-scientific ideas and to function as reliable and replaceable scientific knowledge agents (Wulz 2010), devoted to a “spiritual” form of existence: a life of patience, dedication and self-sacrifice (Bachelard 1938b/1970). In other words, the scientific psyche is subjected to a process of “permanent catharsis” (Bachelard 1947: 18). The scientific style of thinking entails an epistemological “mutation,” distancing it from pre-scientific modes of thought (Bachelard 1938a/1970).⁴ Science requires a “reformation” of the subject, an iconoclastic “destruction” of pre-scientific ways of thinking (1940b/1949: 8), a radical “transformation” of the human psyche and its time-old cerebral mechanism (Bachelard 1938a/1970: 129), a self-imposed “mutation” of human nature (Bachelard 1938a/1970: 144).

This conversion remains an interminable process, however, and pre-scientific convictions will only be temporarily repressed (by the censorship of the scientific method) rather than drastically eradicated. The systematic elimination of pre-scientific conceptions will never be fully completed. Rather than permanently eliminating the irrational from the domain of scientific activity, epistemological obstacles continue to trouble science. Science even needs these obstacles to progress, by overcoming them. Modern science will never completely destroy the imaginative core of pre-scientific experience, and this results in a *Spaltung*, a “division of the subject” (Chimisso 2001: 81). Scientific activity splits the subject into two parts, the one relentlessly supervising and criticising the other. This division of the subject is produced and amplified by technoscience.

Science is *iconoclastic* (Bachelard 1938b/1970: 38: 77; Bachelard 1953: 122). Rather than in the visual image or gestalt of things, science is interested in the molecules and processes that are captured with the help of formulas, symbols, equations and the like (Bontems 2019: 22). Science advances by saying No to its pre-scientific past (Bachelard 1940b/1949). And yet, scientific discourse continues to be susceptible to the imaginary, so that the distinction between *facts* (produced by technoscience) and *fictions* (holding sway in the outside world, as products of popular, imaginative world-views) is relative, rather than absolute. Repressed ideas continue to resurge from the unconscious. This is why, increasingly, scientific research will opt for automation, replacing human researchers by robotics. The disdain for the robot is a pre-modern misconception, Bachelard argues. The electronic robot will be the perfect embodiment of a scientific, rational and quantifying style of thinking (Bachelard 1949/1962: 25).

This praise of scientific method also results in a critical attitude towards philosophy proper. As a philosopher of science, Bachelard criticises Sartre for instance who referred to the continuous wave-aspect of electrons as their “feminine” and the

⁴ “Par les révolutions spirituelles, l’homme devient une espèce mutante” (Bachelard 1938/1970: 16).

discontinuous particle-aspect as their “masculine” dimension (Bachelard 1951: 192). Philosophy should put a stop to such projections, such sexualisations of quantum physics. Philosophers should not act as belated alchemists, retaining a pre-scientific way of thinking. The task of psychoanalysis is to surgically remove such misguiding preconceptions (Bachelard 1953: 18), resulting in a reformation of the intellect. At the same time, Bachelard admires Sartre for the way he, as a psychoanalyst and novelist, in *La Nausée* describes the case history of a person who fails to establish a stable relationship with things in his life-world, who fails to achieve solidity, because all things invoke in him an experience of ambivalence (1948a: 112). And he also praises Sartre for the way he discusses the secret (noumenal, archetypal) darkness of things (the night of the world), for instance: the secret darkness of milk (1948b: 25): an intuitive apprehension of a dialectical tension between essence and appearance, which, for Bachelard, is connected, not only with dialectics (the opacity of matter), but also with the poetic theories of alchemists concerning a mysterious blackness, a dark matter that is blacker than black, *nigrum nigrius nigro* (Bachelard 1948b: 27; see Bontems 2012).

Thus, on the one hand, Sartre is criticised for projecting archetypal images (of femininity and masculinity) on scientific concepts which he, apparently, fails to understand. Such images, Bachelard argues, are screens produced by the human psyche to avoid the confrontation with the threatening Real (Pire 1967: 22). On the other hand, Sartre is praised as a gifted psychoanalyst and phenomenologist when it comes to articulating lifeworld experiences in a literary manner.

Bachelard’s distinction between the symbolic and the imaginary, between technoscience and imagination, was taken up by subsequent francophone authors, notably Jacques Lacan. In Lacanian terms, Bachelard studies the *symbolic* dimension of technoscience (Zwart 2019a) when he analyses how technical contrivances produce a specific type of discourse consisting of numbers, technical terms, neologisms, acronyms, mathematical and chemical symbols, equations, and so forth, resulting in a symbolisation of the Real. Bachelard is also an expert of the imaginary, however, via his depth psychology of literary archetypes. Therefore, his writings amount to a “comparative epistemology” (Zwart 2008): a systematic comparison of scientific knowledge forms with their literary (imaginative) counterparts, seeing novels as literary laboratories (as theatres of the imagination), allowing us to study typical images which, due to the epistemological rupture, are less visible, but nonetheless still active, in scientific discourse. Special attention is given to the *elementary* or *material* archetypes, as we have seen, but also to authors who were fascinated or obsessed by them: Edgar Allan Poe as a poet of water, Heraclitus and Julius Robert Mayer as thinkers of fire (energy), Nietzsche as a philosopher of air, etc. The primal element corresponds with a basic philosophical mood or temperament (1942/1947: 5).

Bachelard’s reading of Edgar Allan Poe (1809–1849) allows us to specify how his approach deviates from traditional (Freudian) psychoanalysis, represented by Marie Bonaparte (1958). Her extensive analysis of Poe’s life and work entails a psychopathography of the author, but Bachelard is exclusively interested in the archetypes at work. He uses written documents only (1942/1947: 14) and explicitly forbids himself to move from oeuvre to author (1942/1947: 81). His primal source of inspiration

is Jung rather than Freud (Bachelard 1938b/1949: 44, 1960: 17: 50; see Pire 1967). Like Bachelard, Jung was intrigued by alchemy as a practice of the Self, projecting unconscious complexes onto chemical, astronomical and other natural phenomena (1948b: 51). Both Jung and Bachelard were interested in how unconscious alchemical ideas continue to affect modern science. Jung analysed the dreams of quantum physicist Wolfgang Pauli, a Nobel laureate who, among other things, predicted the existence of the neutrino, but who also was a prolific dreamer. According to Jung, mandalas (archetypes of wholeness) played a crucial role in Pauli's dreamlife, to compensate for the disruptive impact of quantum physics on established worldviews (Zwart 2018).

The Epistemological Rupture

Bachelard's leading concept is the epistemological break or rupture, separating scientific knowledge (fabricated in laboratories) from life-world experience (as explored by phenomenology, see Vydra 2014). This rupture is first of all a historical event, separating modern science from pre-modern knowledge practices, notably alchemy. The epistemological rupture marks the dividing line between the pre-scientific epoch of a discipline (under the sway of the imaginary) and the scientific one. Modern researchers consistently have to re-enact this rupture, biographically as it were, in order to transform themselves into genuine scientists. It is a transformation which affects both the subject-pole and the object-pole of the knowledge relationship. Modern chemists study chemical processes under controlled conditions and the main objective of Bachelard's *Psychoanalysis of Fire* (1938b/1949) is to explain why fire (as a life-world phenomenon of every-day experience) no longer constitutes a valid object of scientific research. Fire (for instance: a hearth-fire) invokes stories, narratives and childhood reminiscences, but modern science focusses on the noumenal dimension of processes such as corrosion and combustion, representable through structural formula and chemical equations. Experimental researchers study model organisms and other bio-objects that are fully adapted to laboratory circumstances, dramatically different from wildtype relatives. This already applies to the artificial human (the *homunculus*) produced in the laboratory (in vitro) by Faust and his pupil Wagner, a lab creature who spends his life in a crystal vial, a sterile bubble, unable to survive exposure to a normal, messy, unclean environment (von Goethe 1831/1910, 6884; cf. Zwart 2019c).

The researchers themselves (as laboratory subjects) also become affected by laboratory life, however. The most important product of laboratory research as a practice is a particular type of subject: reliable, trustworthy and replaceable, a subject without qualities, "without depth" (Lacan 1966): a "kenotic" subject (Zwart 2016a) in whom established worldviews and life-world convictions have been replaced by the "philosophemes" of modern science (Bachelard 1949/1962: 7). Cathartic elimination of pre-scientific conceptions (via auto-psychoanalysis) eventually results in the *psycho-synthesis* of a scientific mindset, a scientific consciousness. According to Bachelard, it is the vocation of a psychoanalyst of technoscience to elucidate the basic philosophemes of technoscience, the conceptual building blocks of the scientific world-view.

This cathartic process is an interminable endeavour, however, because scientists are divided subjects, as we have seen, unable to consistently live up to their rigorous methodological ideals and hampered by the occasional return of the repressed: the resurgence of prescientific (alchemical) phantasies and ideas. Therefore, scientific discourse requires constant therapy and supervision. Psychoanalysis of technoscience probes the collective unconscious of scientific research, resurging in symptoms such as failures, mistakes, logical inconsistencies, fraud, paralysis, depressions and mid-life crises. Rather than studying science directly, psychoanalysts revert to a different stage or *Schauplatz*, the world of literature, where archetypal images are amplified rather than repressed. Poetry and novels are to science what dreams and day-dreaming (in French: *reverie*) are to individual consciousness, as we have seen. They serve as windows providing access to the unconscious. Imaginative ideas, expelled from sober, de-psychologised scientific discourse, are very much alive in poetry and novels. These genres provide an epistemological reserve where repressed ideas continue to flourish.

While modern science adopted the periodic table, poetic imagination continues to perceive the world in terms of premodern elements (earth, water, air and fire) and the various archetypal complexes associated with them, such as the Mother Earth archetype (connected with earth) or the dream-flight motif (the Icarus complex, connected with air). The time-old association between fire and eroticism (between electricity and eroticism, between friction and arousal, etc.) is discarded by modern science, but still very much alive in belles-lettres, where love is still experienced as electrifying. Another (misguiding) archetypal idea is the concept of the scientific genius, the scientific visionary or clairvoyant, an attractive and motivating phantasy perhaps, which allows researchers to see themselves as exceptional, as chosen ones, endowed with special talents, but this phantasy is quite at odds with how real science operates, namely as teamwork, relying on distributed intelligence, social networks and intense collaboration. The edification of scientific subjects is a socialisation process (Wulz 2010: 22) and individual scientists are supervised by other experts. Scientists should not personalise their knowledge, but rather socialise their convictions, via communications and publications. While anonymity (impersonality) is a characteristic feature of scientific discourse,⁵ originality and genius are literary concepts (Smith 2016: 39).⁶ Unconsciously, however, ideas such as geniality, although formally dismissed, remain active in practice, and precisely for that reason Bachelard produced his parallel series of books which purport to psychoanalyse science from two angles: from the perspective of scientific technicity (the symbolic) and from the perspective of elementary imagination (the imaginary).

⁵ Contrary to Isabelle Stengers' claim, although Bachelard does posit an epistemological rupture between scientific insights and every-day opinion, he does not attribute this rupture (this "conceptual mutation") to the work of "geniuses" (Stengers 1993/2000: 28). Science is team-work and requires collaboration, supervision, surveillance and de-personalisation: a drastic obliteration of the self (Zwart 2016a).

⁶ "[Bachelard] formuliert bestimmte psychosoziale Moment der szientifischen Forschung in einem Vokabular der Kontrolle, Überwachung und Prüfung... Es geht ihm dabei vor allem um Garantien einer—eben kollektiv—überwachten Objektivität... On ne peut plus être rationaliste seul" (Pravica 2015: 155).

The Imaginary

For Bachelard, as far as imagination is concerned, the fundamental signifier (“*vocable*”) is not *image*, but *the imaginary* (“*l’imaginaire*”: Bachelard 1943: 7). There is something seductive and fascinating about the imaginary. It entails an invitation to embark on an oneiric voyage through an imaginary landscape (Bachelard 1943: 10). Whereas classical psychoanalysis (i.e., Freudianism) is iconoclastic, bent on cleansing human consciousness from imaginary remnants (a form of Enlightenment), Bachelard proposes to complement this by developing a “counter-psychoanalysis” (1943: 204), studying the imaginary by purifying it, stripping off everything accidental, until we reach the archetypal core of the imaginary realm. This depth psychology or counter-psychoanalysis (more Jungian than Freudian) is elaborated in books devoted to elementary archetypes, associated with the four elements of traditional (imaginative) metaphysics.

Bachelard claims that an adequate understanding of the imaginary requires a Copernican revolution (Bachelard 1938a/1970, 1943: 119, 1948a: 4, 1948b: 81). According to the traditional view, observation comes first, while imagination uses observations as raw material to fabricate stories, art-works and the like. According to Bachelard, however, our psyche works the other way around. Imagination comes first, providing the a priori structures that allow us to organise and make sense of the overwhelming flow of perceptions. Imagination *precedes* observation and archetypal ideas allow us to contain the chaotic avalanche of empirical phenomena to which we are constantly exposed, guiding our intentionality and allowing us to organise our bewildering experiences into a world-view.

Scientific research works differently, as we have seen. In the case of science, our intentionality is guided by technical contrivances such as telescopes or microscopes. They narrow the field of vision in a radical way and allow research to concentrate on specific microbes, molecules or stellar constellations. Yet, archetypal templates are never completely erased (repressed) once and for all, but resurge in the folds and margins of mainstream discourse, notably in times of crisis, when normal science is challenged by anomalies and frustrations. It is only by becoming acutely aware of the structure and function of these archetypal complexes that they can effectively be dealt with. Yet, in the course of his research program, Bachelard increasingly falls under the spell of the imaginary, as we have seen. Archetypes are now valued more positively and assessed in a more affirmative fashion, so that they become complementary sources of insight, as well as obstacles.

A dialectical unfolding can be discerned in Bachelard’s oeuvre. Initially, human beings are imprisoned in an imaginary world-view (the first moment, M_1), which is challenged and negated by the insights produced by technoscience (the second moment, M_2). Bachelard takes sides with the iconoclastic, negating tendency of technoscience, but eventually opts for a more comprehensive view, seeing technoscience and imagination as complementary. Dialectically speaking, this is the negation of the negation (the third moment, M_3). The negative attitude towards archetypal images (entailed in modern science) is sublated and overcome, and science and imagination become reconciled again (*coniunctio oppositorum*, to phrase it

in Jungian terms). As complementary sources of insight, iconoclasm and imagination now converge into a more comprehensive understanding. In other words, Bachelard's oeuvre reflects a Jungian process of individuation, resulting in a scientific Self which sees the rational and the imaginative as complementary rather than as contradictory (Zwart 2019a).

Iconoclasm and imagination represent two forms of thinking as distinguished by Jung (1911/1968; see Zwart 2019a: 17), namely *rational* thinking (i.e., thinking in terms of tested concepts, mathematical symbols, scientific equations and the like) versus *imaginary* thinking (thinking in terms of images and associations). Imaginary thinking is the older form, reflecting the spontaneous functioning of the human mind, while rational thinking is a relatively recent acquisition, still requiring active exercise. Because the imaginary mode of thinking is "autochthonous" (Smith 2016: 75), science has to learn to "think *against* the brain" (Kotowicz 2018: 32). Important intellectual developments, ranging from the invention of reading and writing via scholasticism up to modern technology have contributed to the dominance of rational thinking, but it has never completely replaced or erased its imaginative rival, so that the tension between the imaginary and the rational continues to exist. Technoscientific research represents a fascinating stage or canton within the deep dialectical history of the human mind. The major shift or turn in Bachelard's oeuvre is that he came to see the symbolic and the imaginary as equally valuable.⁷ Both are worthy of research and in both cases, research aims to transcend the given of everyday experience to disclose a noumenal depth (of atoms and archetypes respectively). Rather than "disqualifying" non-science (Stengers 1993/2000: 28), Bachelard aims to flesh out the unique profile of scientific rationality when compared to imaginative thinking (which gravitates towards archetypal structures). Provided it is used critically (i.e., based on careful analysis), the imaginary may perform an "anagogic" function, allowing scientific research to transcend the given and enter the noumenal real (Castellana 2015).

Elementary Archetypes

In the course of this process of individuation or psycho-synthesis, Bachelard's valuation of the archetypes shifts from a polemical stance towards a more affirmative one. Initially, in *Psychoanalysis of Fire*, Bachelard (1938a/1949) argues that scientists must break away from fire as an immediate object of experience, a familiar phenomenon with all its seductive associations, something which can be intuitively grasped (1938b/1949: 9). In modern chemistry, the signifier "fire" has disappeared and rightly so. It is something only poets still write about. Fire is banned from scientific discourse, no longer counts as an object of inquiry, and this repression is fully *justified* (1938b/1949: 164). And yet, fire (and its complex of associations)

⁷ While scientific research is conducted in "factories" designed to produce trans-natural phenomena, Bachelard at the same time argues that every factory (considered as a concrete realisation of technoscientific knowledge) should have a poetry department (Smith 2016: 97).

is never *completely* erased from scientific practice. Underneath the engineer, the alchemistic mindset lurks (Bachelard 1938b/1949: 14). The same goes for imaginative mental operations such as association, projection and metaphor, representing a primordial, pre-scientific mode of thinking (Bachelard 1938b/1949: 44). Therefore, to fully understand the technoscientific engineer, psychoanalysts of science not only study the manifest logic of science but also explore the persistent alchemical ideas as the unconscious of modern science. Gradually, Bachelard allows himself to become carried away by his analysis of archetypes, becoming increasingly sensitive to their appeal.

The element air is associated with verticality, with ascension and height (Bachelard 1943), with a particular form of upward mobility: the Icarus-complex, the desire to reach unprecedented altitudes, but also the accompanying fear of falling or crashing down into the abyss of emptiness beneath. Ascending and crashing are typical dream motifs, but also standard ingredients of stories and novels about flying, aircrafts or space travel. Plato's story about the soldier Er who, while traveling through the geocentric universe, enjoyed the imaginary music of the spheres (the celestial symphony) falls within this category (Plato 1935/2000: 614–621; Bachelard 1943: 61; Zwart 2012). The element air is connected with the upward gaze of ancient and medieval cosmology, with phantasies concerning the spherical cosmos and its concentric heavenly spheres, but also with the zodiac whose constellations have always served as a "collective Rorschach test" (1943: 202), a heavenly screen onto which psychological ideas were projected since time immemorial (1943: 210). Imagination is a primordial way of thinking, Bachelard argues (1943: 119), relying on associations and projections. And alchemy is a dreamlike type of research, unblocking the imaginary in the realm of human inquiry. This assessment explicitly builds on Jung, who argues that the truth of astrology is that we are able to read something about ourselves in the stars precisely *because* we use these constellations as screens onto which unconscious complexes are projected. That is why the stars predict our future: they reflect the unconscious dynamics of our inner psyche and mirror the psychic contents we transfer to them.

In his book on water (fluidity), Bachelard (1942/1947) again distinguishes mere phantasies (the accidental surface content) from the imaginary as such, the basic structures at work, discernible in daydreams, reveries and literary phantasies (for those who have an eye for them). Again, the target is not the author (the poet), but the literary text itself (1942/1947: 14). Philosophers, Bachelard argues, always read twice: the first time to follow the author (a superficial reading), the second time to reveal the archetypal complexes guiding the author's phantasies (1942/1947: 26), resulting in a depth poetics.

By opting for *Water and its Reveries* as a title (1942/1947: 9), Bachelard indicates that his methodological procedures are shifting from a normative, psychoanalytical approach (1938b/1970: 16) towards a more relaxed, phenomenological one (1957: 156; Picart 1997), but the basic epistemological design remains consistent. For modern science, Bachelard argues, water is basically H₂O. Whether water is polluted or pure can be determined with the help of tests, resulting in scientific indicators (symbols), such as the signifier ("écriteau": 1942/1947: 184) placed beneath a tap to indicate whether it is drinkable. Literary texts adopt a pre-modern stance towards water,

and Bachelard discusses basic associations connected to water: water as a mirror, water and suicide (the Ophelia complex), the nymph taking a bath, thereby crushing her mirror image or mirror double (the Diana complex: 1942/1947: 49) and so on. Edgar Allan Poe's water texts, Bachelard argues, are guided by archetypal ideas (notwithstanding the various pseudo-scientific and pseudo-mathematical ingredients, the technical details, the scientific references, the information concerning latitudes, longitudes, temperature: 1942/1947: 62). Poe's water, according to Bachelard, is heavy, silent, dead and opaque, giving rise to interminable and monotonous adventures. For both Jung and Bachelard, monotony as such is already an indication that a particular archetype is at work: the deceased mother. Water is the dark, antediluvian aspect of our planet, that part which is still flooded, representing otherness and the unconscious. In roman languages, Bachelard points out, the letter *a* stands for water (*aqua*), but also for otherness (*autre*, etc.; 1942/1947: 253).

Although Poe's novel *The narrative of Arthur Gordon Pym of Nantucket* is quite implausible from a scientific point of view, Bachelard discerns a different kind of truth in it, by casting Poe as an "explorer," a "genius" of the aquatic imagination (1942/1947: 63), who develops a "poetical chemistry," a literary analysis of the element water and its various archetypal associations, such as the image of the maelstrom, revealing the frightening but intriguing depths looming beneath the surface (1942/1947: 64), a source of inspiration not only for novelists, but also for oceanographers, ichthyologists, marine archaeologists and deep sea zoologists. The sensitivity and articulacy of authors such as Poe allow us to discern, flesh out and even revivify the archetypal dimension of human experience in a convincing and systematic way. His prose explains what outsiders find so fascinating about oceanography and related research areas, investigating the enigmatic depths of aquatic nature and its weird inhabitants. Literary authors are experts of the imaginary. Whereas technoscience entails a rigorous symbolisation of the world (reframing human knowledge with the help of scientific nomenclature, mathematical symbols, numbers and equations), novels probe and assesses its psychic depths.

Another association is the idea of an alchemical mixture of substances, the love potion or panacea (φάρμακον), or alcohol as a mixture of water and fire (spirit-water). Again, we find these associations in Jung as well. According to Jung, water (dreams about dark lakes or oceans at night, etc.) represents the unconscious as such (1959: 18), but water is also associated with rebirth (the Mother archetype), see the gospel story about the pool of Bethesda, functioning as a panacea (1959: 19).

In the two volumes dedicated to the element earth (1948a, b), Bachelard again argues that, although literary texts seem reproductions of reality, they are actually sublimations/elaborations of archetypes (1948a: 4). Historically speaking, the imaginary is the primordial mode of human self-expression (1948a: 5). Whereas narratives constitute the conscious part, archetypal motifs constitute the unconscious part of literary stories (1948a: 6) and the focus of a depth psychological reading is on these fundamental structures. Therefore, all stories must be read twice (1938a/1949).

Whilst Bachelard's first volume (1948a) concerning the element earth explores *extravert* aspects (images concerning activity and labour), *introvert* aspects (rest, leisure, reflection) are addressed in the second volume (1948b). Earth as primordial matter is associated with the Mother Earth archetype. While modern science

explains biology on the basis of chemistry, the pre-scientific mind explains chemistry on the basis of biology: planet Earth as a living super-organism (1942/1947: 168). Earth is that which offers resistance, but at the same time entails a provocation (Explore me!). Humankind no longer fears or admires terrestrial nature and is tirelessly transforming the environment. Because classical psychoanalysis was a bourgeois endeavour (addressing the urban elite), the world of manual labour remained virtually unexplored. To understand the element earth, attention must shift from the inhibited bourgeois neurotic to the active workers, defined by their equipment and their products. Tools are materialised aggression, reifications of the will to power, oriented towards a future goal (1948a: 37), but recalcitrant matter continues to put up resistance. Whereas from a Freudian perspective all activities are social activities (so that labour becomes an assault unconsciously directed against father figures), Bachelard focusses on the immediate target of the activity: material earth as such.

Labour, Bachelard argues, is an activity guided by the imaginary, an effort to impress geometrical order upon nature. From the standpoint of manual labour, nature is not harmonious at all. Rather, geometric order is enforced by human workers, guided by an image (εἶδος). Egyptian pyramids are archetypal ideas concerning geometrical, crystalline structures of elementary minerals, captured in stone and projected onto a very large scale (1948a: 288). The modern era not only transforms natural materials into artificial useful things, but even produces new materials (e.g., plastics): a dramatic reduction of nature's recalcitrance. Whereas traditional philosophical contemplations only touch the surface of things, labour (and Bachelard sees scientific research as a specialised form of *labour*) acquires genuine, solid knowledge concerning nature. The primeval destructive club of pre-historic times has evolved into a plethora of sophisticated instruments. In Nietzsche, however, Bachelard still discerns a regression to infantilism: the hammer as the archetypal club that merely destroys (1948a: 136). Meanwhile, the tools of modern labour are becoming quite sophisticated, and this notably applies to a specific form of manual labour known as laboratory research, where precision instruments are used to generate robust knowledge. They operate as reified theorems (Rheinberger 2005: 320; Kotowicz 2018: 57), as *Denkzeuge*, thinking-tools (Pravica 2015: 158), no longer extensions of human organs, but materialisations of mathematical theories, designed to realise experimentally what mathematical intelligence predicts (Pravica 2015: 163). Bachelard (who looked upon the bourgeois philosophical milieu of his day quite critically: Kotowicz 2018: 6) sees science first and foremost as experimental, positive metaphysics: a practical endeavour, a form of labour, a praxis, an experimental activity: "science in action," "philosophy at work" (Rheinberger 2005), a synthesis of intellectual and menial (hands-on) components, continuously transforming and transcending the given. Indeed, Bachelard's oeuvre is a panegyric of laboratory labour as a psychotherapeutic exercise (Smith 2016: 96).

Labour always retains elements of self-analysis and self-therapy, resulting in individuation, and this notably applies to technology-based research. It is essentially a practice of the Self, resulting in *selbst-Bildung* (self-edification). In the laboratories of alchemy, labour was still under the sway of the imaginary: projecting archetypal structures onto matter, even on a cosmic scale, so that the purpose of alchemical experiments was to validate imaginary projections. The most decisive outcome,

however, was self-knowledge and self-therapy. In Richard Wagner's *Siegfried*, the smithy serves as a therapeutic setting where the protagonist heals himself, to individuate and become what he is. What is put together again is not only the sword, but also the hero's fragmented identity. In Wagner's opera, the stage becomes an alchemistic soundscape facilitating individuation. From the point of view of alchemy, the whole world is an immense alembic (1948a: 237). Planet Earth is alive so that research is basically "pan-biology" (1948a: 240). The animal realm follows a daily rhythm, the lunar realm a monthly rhythm, the vegetal realm an annual rhythm, the mineral realm a millennial rhythm. While traditional philosophers contemplated nature from a safe distance, modern scientists (as active laboratory workers) develop what Bachelard refers to as "depth chemistry": real knowledge concerning the noumenal dimension of matter (molecules, atoms, protons and so on). Ignoring Kant's bourgeois caveat that we supposedly cannot know things in themselves, laboratory work relentlessly opens up the noumenal dimension of terrestrial nature, giving rise to "noumenal chemistry" (1948b: 11), revealing the inner, dynamical structures of molecules and atoms.

Notwithstanding the discontinuities between modern scientific and pre-modern forms of inquiry, the imaginary is still at work as the unconscious of contemporary technoscience. Geological research, for instance, is like climbing a mountain top (accepting nature's provocation to do so) to enter a Pleistocene environment. Upon reaching the summit, the climber is exposed to a breath-taking, panoramic view of an immense terrestrial body, while human beings are reduced to the scale of insects or microbes inhabiting its skin. This desire, to perceive Earth as a whole, and to miniaturise human beings (1948a: 386), or the other way around: to perceive the human body as a giant ecosystem inhabited by tiny microbial creatures, fuels contemporary research areas. To deepen our understanding of this desire, we may consult genres of the imagination, such as Swift's story about Lilliput, where this drive towards miniaturisation is enacted and elaborated in detail via active imagination. That Jonathan Swift (the author of *Gulliver's Travels*) and Robert Hooke (the author of *Micrographia*) were contemporaries, is no coincidence.⁸ Both the microscope and active literary imagination are techniques for modifying the scale of things. Modern science enables voyages of exploration into our own bodies and allows us to either dwarf or enlarge ourselves in rather dramatic ways (Zwart 2016b).

The Resurgence of Mother Earth

The archetype associated with the element earth invites us to see our planet as a living, caring, nurturing maternal body, a super-organism. From this perspective, sheets of crystallised minerals become veins, apertures (volcanoes rivers) become mouths, caves become wombs: sheltered environments, dwelling places for primordial human beings, where the process of anthropogenesis once unfolded. The

⁸ "La beauté lilliputienne des livres scientifiques qui ont relaté les toutes premières découvertes microscopiques" (Bachelard 1948b: 19).

archetype resurfaces even in scientific discourse, as exemplified by the Gaia-hypothesis (Lovelock 1979; Harding 2006). What Lovelock (1979) announces as a “new” look at life is actually the revivification of an ancient idea, psychoanalytically speaking. Seeing Planet Earth as a super-organism was one of the basic philosophemes of alchemy. From an iconoclastic technoscientific perspective, the affinity of the Gaia-hypothesis with the Mother Earth archetype evokes suspicion. To come to terms with nature, pre-modern archetypal views must be exorcised and replaced by quantified input. As a philosopher of technoscience, Bachelard endorses the iconoclastic tendencies of critical Enlightenment. Archetypes belong to a different, more imaginative, but eventually deceptive mode of thinking, at odds with the rigorous logic of experimental and quantitative research. At the same time, he is well aware of the extent to which archetypal ideas continue to play a role. A more comprehensive view should encompass both the rational and the imaginary, both the conscious and the unconscious components.

A paradigmatic example of the Mother Earth archetype is Plato's simile of the cave, describing a group of human beings dwelling in a subterranean cavern, whose legs and necks are fettered from childhood, so that they can only stare at the wall in front of them. A fire is burning higher up, at a distance behind them, while images of humans and animals are carried about, as in puppet-shows, whose shadows are cast onto the wall (Plato 1935/2000: 514–515). Some prisoners are freed from their chains. Their initial resistance is overruled and they are dragged away towards the light. Psychoanalytically speaking, the projected shadows reflect archetypal shapes. The epistemological rupture takes us from deceptive images to genuine knowledge, freeing us from our imprisonment, leading us upward, literally *educating* us. At the same time, Plato's story adheres to archetypal images and associations itself, depicting the cave as an archetypal cavern where, since time immemorial, initiation rites take place and initiates are allowed to pass or ascend from dreams to ideas (Bachelard 1948b: 203). And the story also resonates with the Mother Earth archetype: picturing the original human condition as a protective cavity reminiscent of a womb, with prisoners as foetuses, chained to their petrified uterus by umbilical cords (fettters). They seem perfectly happy in an environment which in readers may invoke claustrophobic anxiety. At a certain point, they depart from their abode, which apparently satisfies all their needs, and progress towards enlightenment via scientific education. Liberation is a traumatic experience however, a birth trauma, an intellectual awakening. Plato's scene suggests a Palaeolithic hatching facility for domesticated humans, hypnotized by images projected on a screen: a Flintstone-like cinema based on pyro-technology, but perhaps we may also see them as passengers on a transatlantic flight. In short, Plato's simile plays upon the very archetype it aims to replace by true knowledge (e.g., logic, astronomy, geometry).

The Mother Earth archetype can be discerned in modern research practices as well, such as palaeoanthropology. Paleoanthropologists typically look for fossilised early human remains in caves. It was in Sumatran caves that Eugène Dubois (1858–1940) hoped to discover his “missing link” (Zwart 2019a). From 1887 to 1890, while stationed on Sumatra as a military doctor, he systematically explored every single cavern he came across (Theunissen 1989). It was only when he tried his luck on the banks of the Solo River (Java), that he found his *Pithecanthropus*

erectus (*Homo erectus*) femur and skull. The archetypal image of early humans dwelling in tropical caves inspired him to travel to the Dutch East Indies in the first place, but this image became an epistemological obstacle. According to Bachelard (1948b), the cave archetype is part of the Mother Earth complex, as a Pleistocene uterus, a primordial dwelling, resonating in the association between caves and cranes (1948b: 171), not only in terms of alliteration (two instances of C-minor as Bachelard phrases it: the cave as a sombre, primordial human soundscape), but also in terms of their visual shape or *Gestalt*, for the primordial cave is shaped like a crane, inhabited by early human beings (homunculi as it were), while the cave's openings function as eyes or windows into the outside world. According to the logic of imaginative thinking, cave floors are likely places for unearthing early human skulls. In the case of Neanderthal or Homo Naledi (Berger and Hawks 2017) research, this association proved helpful and valid, but Eugène Dubois had to discard it, had to emancipate himself from this captivating image, before he could achieve his goal, replacing it with a substitute vision of early human beings thriving along pastoral river banks. Rather than staging Eugène Dubois as a neurotic, we should consider his work as a force field where technoscience and imagination reinforce or collide with one another.

The rational logic of technoscience and the archetypal logic of the imaginary are depicted by Bachelard as complementary or even compensational as we have seen.⁹ The seductive world of images, myths and phantasies must and will give way to more rational form of agency, exploring the world in technoscientific terms, in accordance with Freud's famous formula "Where *Id* was, there *ego* shall be" (Freud 1932a/1940: 86). Where seductive archetypal images once reigned, the scientific, rational ego must take the floor. At the same time, Bachelard realises that such a cathartic operation requires a depth psychology. Archetypes (primordial images, a priori templates) are the basic constituents of the collective unconscious. While the rational, scientific mode of thinking relies on technology, precision measurements and quantification, imaginative thinking relies on the logic of correspondences, projections and associations. Bachelard's understanding of archetypes is logocentric. He sees them as *discursive complexes*, structuring discourse, giving rise to various *discursive* symptoms. The craft of philosophers is discourse analysis: systematic reading (1948a: 6) and comparative epistemology. Understanding the subject-object relationship requires a mutual exposure of scientific and literary sources (triangulation, Zwart 2016b).

Whereas Bachelard initially considers science as fundamentally superior compared to pre-modern, archetypal modes of thinking, he eventually frames imagination as different rather than deficient. Genres of the imagination provide a different scene where the logic of the archetypes can be systematically explored. After *Psychoanalysis of Fire* (1938b/1949), the term "psychoanalysis" disappears from his book titles. Whereas *Psychoanalysis of Fire* addresses both technoscience and elementary imagination, seeing the latter as deficient, subsequent volumes reflect a trans-valuation of values. Both dimensions are now seen as equally important and

⁹ "Les axes de la poésie et de la science sont d'abord inverses. Tout ce que peut espérer la philosophie, c'est de les rendre complémentaires" (Bachelard 1938/1949: 10).

complementary endeavours. The positive epistemic value of literary daydreams is now underscored in dreamlike titles: “Earth and reveries of Will” (1948a); “Earth and reveries of repose” (1948b), “Water and its dreams” (1942/1964). Daydreams compensate the impoverishment and disenchantment brought about by technoscience.

The Sciences and Their Archetypes

All research fields have their archetypes. The core archetype of chemistry is the explosion (1938b/1949), an association which Bachelard already noticed as a teacher. Adolescent students tend to be bored by formulas, but the chemistry practicum appeals to them, precisely because of the possibility that tinkering with chemical stuff may result in explosions, smoke, nasty smells or a bang. In biographies of prominent chemists, such as Justus von Liebig or Humphry Davy,¹⁰ explosions (both thrilling and uncanny, both fascinating and unsettling) played a similar role. The explosion archetype builds on the infantile urge to play with fire, which is forbidden not only because it is dangerous, but first and foremost because it is a privilege of the father (Bachelard 1938b/1949; Freud 1932b/1950). The idea of an explosion was the oedipal motive that drew Liebig, Davy and others into chemistry in the first place. The appropriation and domestication of pyro-technology represents a promethean emancipation. One may also think of the late medieval monk Berthold Schwarz, an adept of the gothic *scientia experimentalis*, credited with the discovery of gunpowder, but paying for it with his life. Pollution is an explosion of chemicals at a slow pace and on a large scale, resulting in proliferation of pesticides, a biological catastrophe, a “silent spring” (Carson 1962).

The archetype of biology is the monster: the concrete materialisation of nature as frightening and overwhelming (*δευρός*). Biology is fascinating to outsiders as soon as the monstrous is brought to the fore. The classic exemplification of the biological monster is the *dinosaur* (the terrible reptile), a signifier coined by Richard Owen in 1840. Palaeontology is a fascinating field, excavating the remains of enormous creatures, reconstructing their image, their *Gestalt*, preferably in full colour and large as life—as extinct icons of a lost Jurassic world (Gould 1996: 223). For Bachelard, the literary paragon of the monster archetype is Mary Wollstonecraft's novel *Frankenstein*. Initially, Victor Frankenstein immerses himself in the writings of the alchemists (“necromancers” Mary calls them). Their grand, fantastic theories appeal to him. At the University of Ingolstadt, he is exposed to the iconoclastic logic of modern science, apparently an unassuming and tedious research practice. Initially, he is deeply disappointed by what modern science has to offer,¹¹ until he discovers that scientific

¹⁰ The same goes for Percy Bysshe Shelley on whom Mary Wollstonecraft modelled Victor Frankenstein: “Shelley's attitude to science was [imaginative. He was] the chemist in his laboratory, the alchemist in his study” (Holmes 1974: 16).

¹¹ “The ambition of the [modern] enquirer seemed to limit itself to the annihilation of those visions on which my interest in science was chiefly founded. I was required to exchange chimeras of boundless grandeur for realities of little worth” (Wollstonecraft-Shelley 1818/1968: 306).

research is actually driven by unconscious desire: to create artificial life in the laboratory. He now fully exposes himself to the scientific mode and after “incredible labour and fatigue” he finally achieves his goal. Terrified by the spectacular success of his experiment, however, he flees from his laboratory and suffers a nervous breakdown, unable to continue his scientific work.¹² Victor tries to resume a more poetic mode of existence, but science has irreversibly infected him and the result is an epistemological neurosis, paralysing him, intellectually, erotically and socially (Zwart 2008, 2010). Mary Shelley’s novel provides a case history for a psychoanalysis of technoscience, a different scene where tensions and dilemmas of modern technoscience are *worked through* and *acted out*. The same archetype can also be discerned in the micro-monsters of molecular biology: genetically modified microbes which may escape from the laboratory, creating havoc in the outside world, unleashing an anthropogenic cataclysm, when containment proves impossible (Rifkin 1998/1999).

Bachelard’s final publication is a retrospect (Bachelard 1960: 64) which positions the two dimensions of his oeuvre with the help of a Jungian scheme, based on the distinction between *animus* (the principle of activity, upper level) and *anima* (the principle of passivity, lower level) as well as between research (left side of the scheme) and imagination (right side of the scheme):

Modern technoscience (<i>animus</i>)	Active poetic imagination (<i>animus</i>)
Archetypes of alchemy (<i>anima</i>)	a priori archetypal templates (<i>anima</i>)

What this quaternity indicates is that the *massa confusa* of primordial nature (the Lacanian “Real”) can be approached from two directions. Iconoclastically via technoscience (the *animus* principle of rational activity), resulting in processes of symbolisation, or via the imaginary, via active literary imagination. Both poles have their own duality as well, however, reflecting an internal *animus-anima* tension. In technoscience, the *animus* dimension is experimental intentionality, enhanced by technicity and advanced mathematics, revealing the noumenal, molecular and informational structure of life, energy and matter, while the *anima* side of modern technoscience consists of resurging, imaginary, archetypal ideas (the collective unconscious of scientific discourse). Whereas alchemists transferred and projected a priori ideas onto natural processes, in modern science these complexes and associations are repressed by scientific discipline (the *animus* principle) so that they function in an unconscious manner, but the basic dynamics is still discernible (for those who have an eye for it). In poetic and novelistic reveries, these images are elaborated in a conscious, uninhibited, exuberant manner (the imaginative version of the *animus* principle), but on closer inspection, a priori templates or structures actually guide the process (so that active imagination builds on passivity and receptivity as well: the *anima* principle). Imagination is the other (reverse) side of technoscience, but

¹² “I had conceived a violent antipathy even to the name of natural philosophy... The sight of a chemical instrument would renew all the agony of my nervous symptoms... I had acquired a dislike for the room which had previously been my laboratory” (Wollstonecraft-Shelley 1818/1968: 328).

both dimensions have an inner duality, so that we are actual dealing with a “quadru-
pole situation,” involving four positions (1960: 70).

Bachelard elucidates his scheme with the help of Nietzsche's oeuvre. For Bachelard (again, fully agreeing with Jung), Nietzsche is first and foremost the author of *Thus Spoke Zarathustra*. By announcing the twilight of the idols, he seemingly advocates iconoclasm and radical Enlightenment (the intellectual version of the *animus* principle, upper-left position). We modern humans should emancipate ourselves from religious and metaphysical idols of Christianity once and for all. What he apparently fails to realise, Bachelard argues, is that this attitude of uncompromising hyper-masculinity (the *animus*-principle) is actually a ferocious compensation for the lost pastoral “paradise” (1960: 50) of his youth, the atmosphere of Christian piety (the *anima*-dimension: lower-left position). Writing *Zarathustra* is a practice of the Self, an effort to free himself from these shackles so to speak, but once again Nietzsche (although proclaiming himself to be a psychologist) fails to realise that his opus magnum (his exercise in active imagination, upper-right position) is actually written under the sway of an archetype, the archetype of the prophet, descending from the mountain cave where he experienced his moment of enlightenment:

Radical iconoclastic Enlightenment (<i>animus</i>)	Active imagination: Zarathustra as a literary figure (<i>animus</i>)
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Pastoral pietistic paradise (<i>anima</i>)	The prophet archetype (<i>anima</i>)
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Whereas in the case of night dreams our cogito is suspended, in literary reveries the author can and should maintain a certain level of conscious presence and self-control (Bachelard 1960: 129). The poet (upper-right position) represents an intermediary position between the scientist (upper-left position) and the medium (lower-right position). Whereas technoscience aims to separate concepts from images (1960: 182) and to cleanse concepts from their imaginary ballast (upper-left position), mediums succumb to the archetypal image (lower-right position), and this is what befalls Nietzsche's *Zarathustra*. True poets and novelists (Poe, Baudelaire, Sartre, Lautréamont, etc.) are able to synthesise the two (the obscure and the disciplined forces of human existence: 1940b: 148). In terms of the quadropole scheme:

Science: cleansing rational concepts from imaginary remains (<i>animus</i>)	Novels: elaborating archetypal images in an active manner (<i>animus</i>)
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Alchemists: understanding nature through projection of archetypal images (<i>anima</i> principle)	Mediums: a priori archetypes take possession of the author (succumbing to the <i>anima</i> principle)
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Concluding Remarks: Iconoclasm and Imagination as a Dialectical Interaction

This quadruped scheme, however, must be read as a dynamical, rather than as a static structure because, according to Bachelard, modern scientific thinking is inherently dialectical (Kotowicz 2018: 52), which explains why his epistemology is profoundly dialectical as well. Bachelard aims to develop a dialectical phenomenology of scientific research practices. The first moment of the knowledge process consists of primary intuitions triggered by immediate observations (M_1), a stage of thinking which is under the sway of archetypal ideas (the anima principle), but in an unreflective, spontaneous manner. Nature is described and understood in *general* conceptual terms: in terms of a worldview. The epistemological rupture of modern science represents the second moment: the moment of negativity (M_2) where observation and association are replaced by the symbolism, nomenclature and equations of modern physics, chemistry and mathematics. Science emerges as a *particular*, exceptional way of interacting with the world. The active negativity of science is radical and self-destructive, spoiling its own successes by constantly criticising and negating temporary insights, replacing them with more convincing results. This gives rise to a contradiction between science and non-science, a split or tension between iconoclasm and imagination, between science and literature as two cantons of culture.

This split is also reflected in Bachelard's own oeuvre. At the object pole, there is the rift between the phenomenal and the noumenal, at the subject pole between subjectivity and objectivity. Science is hampered, but also challenged and intrigued by obstacles. Drawbacks become crucial experiences as painful, negative experiences of falsification and contradiction are incorporated and transformed into positivity (Pravica 2015: 16). Finally, *concrete* research projects emerge as moments of convergence between iconoclastic rationality and anagogic imagination. Both the rational and the imaginary enable us to transcend what is immediately given, so that scientific research becomes sur-rational. Initially, rationalism and imagination seem to guide us in juxtaposed directions (quantification versus reverie), as scientific rationality (M_2) urges us to transcend the imaginary (M_1) so as to achieve a symbolisation of the real, but according to the logic of dialectics, a revised epistemology must eventually include what it initially denied (Smith 2016: 42). Only via a negation of the negation (M_3) can the noumenon (as something which is initially negative: a boundary, something allegedly beyond the reach of human understanding) be sublated into a realm of positive research. Likewise, although modern chemistry emerges as antithetical to alchemy, it will eventually evolve into biochemistry, transcending the boundary (allegedly insurmountable) between the non-living and the living, the abiotic and the biotic. Genuine scientific breakthroughs occur when rationality becomes "sur-rational," i.e., when the imaginary joins forces with critical reflection (M_3) to become positive (experimental) metaphysics: a scientific research praxis which is inherently philosophical.

A similar dialectical unfolding can be discerned in the resurgence of the Mother Earth archetype as Gaia. Initially, during the day-break of metaphysical thinking, nature emerged as an all-encompassing whole, with planet Earth as a super-organism (M_1). This vision was negated by modern science, proclaiming the Great

Goddess dead, developing research areas specialised in symbolising and quantifying the Real, such as geometry, geology and oceanography (M_2). Now Gaia has returned, however, albeit under different conditions, as Bruno Latour (2011/2015) argues, emphasising how Gaia is different from “Nature of the olden days” (M_1). Notwithstanding resistance from scientists, who consider the Gaia-hypothesis “unscientific” (M_2), Gaia has become a scientific concept (Latour 2017). Geology became “Gaialogy,”—a convergence of quantification and holism: a third moment, dialectically speaking (M_3). Whereas geology was conducted by allegedly “disinterested” observers from an outsider perspective (a view from nowhere), Gaia is studied *from within* by researchers who experience themselves as part of the earth system so that Gaia-science differs from geo-science, Gaia-politics from geo-politics. Here again, the archetype assumes an anagogic function, allowing us to transcend the restricted scope of pre-Gaia forms of inquiry.

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