Chapter 4
Psychoanalysing Technoscience

While the previous chapter discussed the shift from Hegelian dialectics to dialectical materialism, this chapter addresses the shift from dialectics to psychoanalysis, notably in France, paying due attention to the productive tensions between both approaches. After a concise exposition of Freudian psychoanalysis, focussing on *Beyond the Pleasure Principle*, the text in which Freud explicitly "plunged into the thickets" of modern biology (Gay, 1988, p. 401), I will extensively discuss the views of Gaston Bachelard and Jacques Lacan on technoscience. Building on a previous publication (Zwart, 2019a), where I already presented a psychoanalytic understanding of technoscience, which I don't want to duplicate here (focussing on the oeuvres of Sigmund Freud, Carl Gustav Jung, Gaston Bachelard and Jacques Lacan), I will now emphasise the continuity between dialectics and psychoanalysis, indicating how dialectics remains an important moment in Bachelard's and Lacan's efforts to develop a psychoanalysis of technoscience, both as a discourse and as a practice. In addition, I will elucidate the added value of this convergence by extrapolating it to three concrete case studies, one borrowed from particle physics and two from life sciences research: the Majorana particle, the malaria mosquito and the nude mouse.

Psychoanalysis and the Psychic Machine

According to Sigmund Freud (1920/1940), to come to terms with processes of knowledge production, we should not start from the idea of a pre-established harmony between subject (psyche) and object (external reality). Rather, our point of departure should be the chronic disparity between both poles. The initial encounter with the threatening real is a traumatic experience, exemplified by the trauma of birth. As Slavoj Žižek (2016/2019, p. 157) points out, Kant already interpreted the screams ("Geschrei") produced by a child at birth as a symptom of indignation in response to the experience that human autonomy is significantly hampered by bodily constraints. For psychoanalysis, the birth trauma emphasises the

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maladaptation of the human organism to its natural (primal) environment. An important objective, of organisms in general, but of the human organism in particular, is immunisation against the real.[1] Contrary to most other mammals, human beings enter prematurely into their world, marked by negation and lack: the *absence* of fur and claws, the *inability* to move and walk, so that, with the help of technology, additional immunisation devices (a cradle, a baby carrier, a home, etc.) must be installed to compensate for this lack (negating the negation). Rather than being "open" to externality and otherness, averting, neutralising, and incorporating external input becomes a key existential challenge.

These views are already proposed by Freud during the early years of psychoanalysis, in his letters to Wilhelm Fliess and in an unpublished manuscript known as the *Entwurf*. In these documents, Freud describes the human psyche as a "machine" (Freud, 1950, p. 139), an "apparatus" (p. 270) consisting of various "systems", wherein energy quanta circulate, designed to attenuate excessive stimulation and excitation. Indeed: "I am a machine" (p. 271; cf. Zwart, 1995). The main function of this machine (the neural apparatus) is to act as a screen (a "Quantitätsschirm") to contain the influx of potentially disruptive energy quantities, entering the system from outside (p. 390). The psychic apparatus acts as a filter which allows only small quotients of external energy quantities to affect the psychic system (p. 394). Thus, the main task is to protect the system from intrusion of disruptively large quantities. At first glance, the role of the "reality principle" seems to be to enhance the ego's ability to defer immediate gratification (pleasure). Yet, on closer inspection, the role of the reality principle first and foremost is to *shield* the ego, by forfending traumatic *confrontations* with raw reality. The primary role of the reality principle is not to *expose* the subject to the inexorable real, but rather to allow *carefully selected bits of reality* into the system, so that these "raw quantities" can be processed and transformed, and reality becomes livable for the ego. In short, whereas traditional philosophy emphasises world-openness and intentionality as starting point for human understanding, psychoanalysis rather emphasises the epistemic role of resistance as a mechanism of defence (Zwart, 2019a).

This line of thinking is taken up by Freud many years later, in *Beyond the Pleasure Principle* (Freud, 1920/1940). The pivotal role of resistance, Freud argues, is underscored by human anatomy. We are covered by protective skin (which again is covered with an extra protective layer known as clothes), while our sense organs are miniature apertures whose primary purpose is to provide protection against overstimulation (*Reizschutz*). Rather than being open to the world, our bodies protect and immunise us from the threatening Real. This tendency of living organisms to insulate themselves from the outside world already applies to microorganisms, coaxed inside their cell membranes. Our vulnerable bodies protect

[1] Dialectically speaking, the syllogism takes us from tranquillity *in utero* (M_1) via the trauma of birth (M_2), counteracted by parental support and immunisation, up to relative independence ("autonomy") as an *outcome* (M_3). The prematurity of humans *radicalises* the moment of negativity (M_2), so that culture and technology are needed to bridge the gap towards attaining the negation of the negation ($M_2 \rightarrow M_3$).

themselves against overstimulation, but this applies to the human psyche as well. Protection against external stimuli is a life task at least as important as sensitivity and receptivity (Freud, 1920/1940, p. 27). Our sense organs are like little antennae that select small samples of exteriority, allowing us to assess minute quantities of input. Our primary objective is to safeguard our psychic integrity from intrusive traumas.

Freud elucidates the topology of the human psyche by comparing it with the anatomy of the human eye. Darkness is the default, and the eye is basically a camera obscura, while pupil and cornea allow only small samples of diffracted light to enter the eye and reach the retina (cf. § 2.4). Raw light is filtered and processed. We may also compare the psyche to a laboratory, again a space where everything (light, air, temperature, etc.) is meticulously conditioned and controlled: safeguarded from external disturbances, so that only carefully selected samples of reality are subjected to analysis, with the help of contrivances and agents, as Marx also argued (1867/1979; p. 12). Gradually, the scope of our vision is broadened with the help of artificial extensions, artificial sense organs and electronic gadgets, so that humans gradually evolve into "prosthetic superhumans" (Freud, 1930/1948). Thus, after immunisation and selection, the next challenge is overcompensation. In the global environment of today, humans are exposed to technologically mediated overstimulation (information overload). While laboratories may be considered as materialisations of Freud's concept of the psyche (operating as an immunisation device), the currently emerging global networks of laboratories are confronting us with informational overabundance (data litter). Knowledge scarcity has given way to Gargantuan data collections. Let this suffice as a starting point for outlining a psychoanalytic approach to understanding technoscience. I will now zoom in on the work of two authors who made major contributions to the further development of this approach.

Gaston Bachelard: The Inherent Dialectics of Technoscience

Gaston Bachelard's philosophy of science is a *psychoanalysis of technoscience*, focussing on the epistemological rupture between pre-scientific and technoscientific ways of being-in-the-world, and on the crucial role of surveillance in technoscientific research (Zwart, 2019a, 2020a). Bachelard thematises the rupture between "pre-scientific" and "scientific" as a rupture between imaginative and symbolic styles of thinking, arguing that science is iconoclastic, negating the archetypal images and worldviews that dominate pre-scientific contemplation, and replacing them with the (mathematical, physical and chemical) symbols, equations and neologisms of exact or calculative thinking. In erudite historical analyses he elaborates a theme that was already addressed by Hegel (cf. § 2.12), namely the diremption of ancient elements (earth, water, air, fire) into elementary chemical components (chemical elements). For modern chemistry, Bachelard (1938/1949) argues, while water is being redefined as H_2O, fire as a life-world phenomenon (associated with images of hearths, fireplaces, campfires, torches, etc.) is no longer a valid concept.

It is replaced by validated scientific concepts such as "energy" and "combustion" which can be captured in equations.

Subsequently, Bachelard demonstrates how, for those who have managed to adopt and internalise the logic of science, methodological norms function as a *super-ego*, critically monitoring technoscientific research practices, urging researchers to recognise and overcome their epistemological deficiencies and obstacles. Technoscience is presented by Bachelard as a formative and transformative praxis, drastically affecting the external environment while at the same time converting the individuals involved into reliable subjects: egos of technoscience. 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,[2] via systematic scientific training, a formative process which amounts to a spiritual "reformation" (Bachelard, 1938/1970, p. 23). In short, Bachelard describes the subject-object interaction as a dialectical dialogue which transforms and affects both poles.

According to Bachelard, a dialectical unfolding can be discerned in technoscience. Initially, human beings are imprisoned in traditional worldviews, under the sway of archetypal images (the first moment, M_1). These worldviews are relentlessly challenged and negated, however, by the disruptive insights produced by technoscience (the second moment, M_2). Indeed, according to Bachelard, technoscience is decidedly *iconoclastic*, and in a significant part of his oeuvre, Bachelard emphatically takes sides with the iconoclastic, negating tendencies of technoscience (Zwart, 2019a, 2020a). Eventually, however, Bachelard opts for a more comprehensive approach, seeing technoscientific negation and poetic imagination as complementary dimensions of human experience. Dialectically speaking, this is the negation of the negation (the third moment, M_3). The negative attitude towards archetypal images is sublated and overcome, to that technoscience and imagination become reconciled again. And indeed, technoscience is a prolific producer of powerful images (the Big Bang, the Rutherford-Bohr model of the atom, the Double Helix, etc.).

Bachelard's psychoanalysis of technoscience entails a dialectical "phenomenology" (in the Hegelian sense) of technoscientific research practices as they emerge on the scene in the course of history. During the first (pre-scientific) stage, poetic intuitions are triggered by observations via natural sense organs (M_1), a stage of thinking which is under the sway of archetypal ideas, functioning in an uncritical and spontaneous manner and resulting in poetic, animistic and mythological worldviews. Nature is described and understood in *general* terms (in terms of a worldview). The epistemological rupture of modern technoscience represents the second moment: the moment of negativity (M_2), where poetic experience is replaced by the technical prose of acronyms, neologisms and mathematical equations, generated by experimental research practices. Science gives rise to *particular* ways of interacting

[2] Cf. Engels' view on science as a process of "moulting", a shedding of protective (immunising) ideologies, a metaphor he adopted from Liebig (discussed in the previous chapter).

with the world. The normal *modus operandi* of technoscience consists in tearing things apart. The active negativity of technoscience is not only relentless, but also self-destructive, constantly spoiling its own achievements by criticising and negating temporary insights, replacing them with more convincing and *concrete* results. Finally, genuine scientific breakthroughs occur when rationality becomes "surrational", i.e. when imagination joins forces with advanced mathematics and critical reflection (M_3) to produce astonishing results in the context of research practices which are inherently *philosophical* (e.g. quantum physics), albeit not in the traditional sense of the term. Thus, technoscience discloses a surreal world which seems dramatically at odds with natural intuitions.

According to Bachelard, technoscience is driven by a dialectical logic. To elucidate this, I will zoom in on Bachelard's use of the term "dialectics", reading him aloud as it were. I will discuss those publications in which the concept of dialectics is explicitly addressed, namely *Atomistic Intuitions* (published in 1933), *The New Scientific Spirit* (published in 1934), *The Formation of the Scientific Mind* (published in 1938), *The Philosophy of No* (published in 1940), *Applied Rationalism* (published in 1949), *The Rational Activity of Contemporary Physics* (published in 1951) and, finally, *Rational Materialism,* published in 1953 (the year of the discovery of DNA, but also the year in which Jacques Lacan inaugurated his famous Seminar).

Psychoanalysis and Dialectics

In *Atomistic Intuitions* (1933/1975), Bachelard presents the atom as a prototypical object of technoscience, precisely because it is an "impossible" object (from a traditional philosophical point of view), giving rise to multiple contradictions and anomalies. First of all, Bachelard agrees with Hegel that the concept of the atom as envisioned by ancient and modern atomists was a *metaphysical* concept, developed on the basis of intuitions, such as the image of particles of dust randomly floating in air (M_1). Until the dawn of modern chemistry, the atom was an imaginary entity, and ideas concerning the shape, surfaces, qualities and interactions of atoms were products of speculation, imagination and free association. At the same time, the concept concurred with practical experience, notably the experience that, notwithstanding human effort and labour, everything inevitably returns to dust: to the inchoate chaos of pulverisation. All is vanity, and sooner or later, everything will be disrupted and *negated* (M_2). Therefore, Aristotle's conception of a thing as a synthesis of form and matter was *not* a primary intuition, but the *result* of a dialectical process of working-through (M_3, p. 24). Aristotle's concept was the negation of the negation, i.e. a refutation of the atomistic idea that reality is *nothing but* atomic particles floating and temporarily coalescing in a void. For Aristotle, a living organism (as a consistent, organised, self-sustaining and self-reproducing entity) *is* in itself an irrefutable negation of ancient atomism.

For Aristotle, moreover, the concept of a void (a vacuum) was an ontological oxymoron. Modern science allegedly demonstrated that (in contrast with Aristotle's teachings) a vacuum *can* exist. Yet, as Bachelard emphasises: *not* "in nature". The modern vacuum is an artefact, created with the help of technical contrivances (such as the air pump). Such a vacuum is a technical (unnatural) state, and this entails an important lesson. According to Bachelard, technoscience does not study nature directly. A laboratory is an artificial setting where man-made phenomena are produced and studied under technological conditions.

It was only in the twentieth century that the atom (initially a metaphysical entity, giving rise to incompatible and contradictory interpretations) became truly an object: an object of technoscience. Via a dialectical interaction between advanced technology and advanced mathematics, technoscience revealed that atoms are *not* material substances in the traditional sense of the terms (minima of matter), but composed of subatomic particles with wave-like properties, vibrating and oscillating in a void. Moreover, the structure of atoms can only be explored with the help of technoscientific contrivances, which themselves should be considered as reified theorems: embodying theoretical convictions. As Bachelard would later phrase it, the atom is not a material object, but a "sur-object", constantly hovering between theory and experience, between noumenon and phenomenon, the result of dialectical processes of interaction (not only between particle and wave, but also between observation and computation). In "empirical" technoscience, moreover, the moment of "observation" is often compressed to a minimum (a fraction of a second). Therefore, traditional metaphysics should give way to a meta-*micro*physics, equipped to explore this dialectical *interaction* between advanced technology and advanced mathematics, between "observation" and computation.

This idea is taken up in a subsequent publication entitled *The New Scientific Spirit* (1934/1973). According to Bachelard, the "spirit" of technoscience vindicates the validity of the Hegelian conviction that *the real is rational*. The new scientific spirit (= the spirit of technoscience) is the result of a dialectical "rapport" between scientific reality (technology-mediated observations) and computational rationality (p. 12). The spirit of technoscience is relentlessly self-critical and not discouraged by experiences of opposition or negation. Rather, the spirit of technoscience is bent on putting its theoretical convictions to the test, in order to learn from experience. A technoscientific trial is neither purely phenomenological (descriptive) nor purely rational (apodictic), but involves a dialectical interplay between the rational and the real, mediated by technoscientific thinking as reified in technoscientific contrivances. Research instruments are technical materialisations of ideas, and what a technoscientific experiment aims to achieve is the *realisation* of a noumenal idea in the form of a technoscientific phenomenon: the coming-into-being of a rational world under radically technological conditions. Thus, technoscience is basically a form of dialectics, albeit more instructive than the "ponderous dialectic" of traditional philosophy (p. 18).

Bachelard discerns an epistemological rupture in philosophy around the year 1800, separating Kant from Hegel. While Kant constructed his epistemology on the basis of Euclidean geometry, it is no coincidence that the emergence of

non-Euclidean geometry coincided with the development of Hegelian dialectics, Bachelard argues. Non-Euclidean geometry was initiated by Gauss (in 1813), Schweikart (in 1818) and others in the beginning of the nineteenth century, precisely when Hegel was developing his views. Contrary to apodictic and deductive Euclidean geometry, non-Euclidean geometry is a profoundly "dialectical" endeavour, Bachelard contends (p. 24). Non-Euclidean geometry exemplifies the dialectical spirit at work in technoscience, because it shows how scientific breakthroughs are instigated by instances of crisis (the scientific revolution as the negation of the negation, the sublation of a crisis).

A similar idea is developed in *The Formation of the Scientific Mind* (Bachelard, 1938/1970). Again, Bachelard emphasises the *dialectical* nature of technoscientific experience. Driven by suspicion with regard to established, intuitive views (M_1), technoscience sets out to study phenomena systematically, under different (contrasting) conditions (M_2, p. 16). Alchemy differs from technoscientific chemistry in that it aimed to verify intuitive understandings (under the sway of archetypes). Therefore, it was a research practice destined to interminable failure: the chemical version of what Hegel refers to as an "unhappy consciousness" (p. 49). It was only by systematically comparing contrasting experiences and by exposing intuitive and imaginative convictions to refutation and negation (M_2) that modern science eventually produced concrete, valid and replicable results (M_3).

The dialectical logic of technoscience is explored in depth in two subsequent publications, first of all in Bachelard's *Philosophy of No* (1940/1949). Philosophy should not opt for an apodictic stance, Bachelard argues. Rather, he agrees with Hegel that the owl of Minerva takes flight at dusk. For the hour of philosophy to ring, technoscience must already have done its work. And work (labour) is a dialectical experience, a dialectical interaction with matter and reality, a dialectic of action versus reaction, of transformation versus resistance, etc. (cf. Bachelard, 1948). This same dialectic is discernible in technoscientific labour. Scientific insights result from a dialectical interplay (1940/1949, p. 5) between two apparently contrasting poles, namely (mathematical) *rationality* and (technologically modified) *experience*, between the *noumenal* and the *phenomenal*, the *a priori* and the *a posteriori*. In other words, technoscientific experience is a *dialectically structured form of experience*, where primary observations are systematically exposed to contrasting conditions on the basis of rational predictions. Starting from *general* principles, technoscientific phenomena are exposed to *particular* conditions in order to acquire *concrete* results (p. 4). Technoscientific research is the *realisation* of an idea, evolving into a research program (p. 6). Likewise, there is a dialectical relationship between theory and application, for application means: exposing theorems to unexplored circumstances, to "otherness", in order to incorporate the results of these experiences into the body of knowledge (p. 7). The spirit of technoscience entails a relentless process of self-transformation, with new experiences *negating* previous experiences – hence the title, for the dialectical logic of technoscientific experimentation implies that new experiences negate (say "No" to) previous ones (p. 9).

The role of technoscientific instruments is crucial here. A thermometer, Bachelard explains, is already the materialisation of a theorem, while the use of thermometers

drastically affects the scientific ego's way of being-in-the-world. Such instruments reflect an awareness of the finitude, the inherent deficits of our natural sense organs. They symbolise a "No" to non-validated forms of experience. This "No" does not imply that technoscience equals nihilism, however. Quite the contrary, Bachelard argues, because the end result of the dialectical process is something positive and rational, – or rather: "sur-rational", for it results in opening up the surrealistic worlds of contemporary technoscience, disclosing the noumenal, molecular structures of what in Kantian philosophy is diffusely referred to as the thing-in-itself or "substance" (p. 59), thereby enabling a dialectical turn in philosophy. Technoscience is profoundly dialectical and non-Kantian, saying "No" to the either–or of binary thinking (to Kantian dichotomies such as theoretical versus practical philosophy, the noumenal versus the phenomenal, the a priori versus the a posteriori, waves versus particles, and so on). Infected by technoscience, philosophy becomes transformed into dialectical thinking, or *genuine* thinking, resulting in Bachelard's key adage: "dialectiser la pensée!" (p. 17).

According to Bachelard, technoscience (contemporary chemistry for instance) is decidedly non-Kantian. Spectroscopy is a dialectical research field studying the *interaction* between matter and energy, particles and waves, etc. An electron, for instance, is not a "substance", it is a *dialectical* entity (p. 63), hovering between noumenon and phenomenon, between particle and wave. The logic of technoscientific thinking is profoundly dialectical (p. 105 ff.), subverting the law of non-contradiction (the binary logic of either–or), while in physics and chemistry the focus of intentionality is displaced from objects to sur-objects (atoms, electrons, hydrogen bonds, etc.). Again, although the philosophy of technoscience says "No" to many tenacious philosophical convictions, we should not see it as mere *negation* (p. 135). There is a positive result, namely knowledge concerning sur-objects, where the noumenal and the phenomenal, advanced mathematics and technoscientific experience coincide.

Whereas Bachelard posits an epistemological divide between Kantian epistemology and the dialectical philosophy embodied in technoscience, he is somewhat ambivalent when discussing the relationship between the dialectics of technoscience and Hegelian dialectics. On the one hand, he stresses discontinuity between the two, albeit on the basis of a (remarkably) crude understanding of Hegelian dialectics. Whereas (according to Bachelard) Hegelian dialectics proceeds from "thesis" via "antithesis" to "synthesis" (p. 135), technoscience rather sees thesis and antithesis as "complementary" (p. 136). Precisely this, one could argue (seeing binary opposites as complementary moments of a comprehensive approach), is what is at stake in Hegelian dialectics. In other words, when it comes to fleshing out the profile of the dialectics of technoscience, we notice a remarkable but unfortunate unevenness between Bachelard's acute understanding of the dialectics of technoscience compared to his rather crude understanding of and limited familiarity with Hegelian dialectics. To the extent that our understanding of the latter becomes more elaborate, however, the continuity between Hegelian and technoscientific dialectics becomes increasingly pronounced. And indeed, Bachelard himself agrees that philosophical and technoscientific dialectics seem to approach one another more and

more closely – here, Bachelard even uses the word "approchement" (reconciliation, p. 136). In technoscience, for instance, a negation does not merely imply opposition. Rather, the opposite poles continue to be "in contact with" each other, and the negating position even "includes" or "envelops" what it negates (p. 137), – for instance: the concept of the atom includes both positive and negative components, while non-Euclidean geometry can be seen as negating, but also as *including* (sublating) Euclidean geometry.

In *Applied Rationalism* (1949/1962), we encounter a more developed view on the relationship between Hegelian dialectics and the inherent dialectics of technoscience. Some of the themes already discussed in previous publications are taken up again. For instance, Bachelard again stresses the importance of precision instruments in combination with surveillance, explaining how the latter plays a double role. Not only individual researchers, also established methodologies are put to the test by permanent surveillance (by the Über-Ich of technoscience, p. 80). Therefore, technoscientific research is always work-in-progress. It is an *active* philosophy, a philosophy of the Servant, a philosophy that *works*: a *hormology* (where the Greek term ὁρμώ / ὁρμαώ – means to arouse or to excite, p. 100). For indeed, technoscience works like a hormone: arousing philosophical reflection. Technoscience entails an epistemological rupture in philosophy, replacing a crude and abstract metaphysics with an advanced and validated one. To achieve this, philosophy must become acutely aware of what is happening in contemporary technoscience. For instance, Hegel is complimented for having understood polarity as an inherent dimension of matter as such (p. 139). This is confirmed by current insights into the polarity of matter (the dialectical relationship between electrons and protons in modern chemistry for instance, or between electron and positrons in particle physics).

The disclosure of the noumenal dimensions of energy and matter is only possible through the use of advanced technologies such as spectroscopy, studying the *interaction* between matter and electromagnetic radiation. Therefore, spectroscopy is a philosophical or even a *dialectical* technology (p. 103), supporting a noumenal approach to technical phenomena, allowing us to enter a surreal world which is far beyond the constraints of Kantian epistemology. Technoscientific contrivances are reified theorems, concrete materialisations of philosophemes (p. 103). Edison's electric light bulb, for instance, is an abstract-concrete object, a product of technoscientific *thinking* (in Hegelian terms: a concrete universal). All technoscientific objects are bi-objects (p. 109), Bachelard argues, both phenomenon and noumenon (p. 109): a condensation or convergence of ideas giving rise to new ideas. And while Schelling deplored that phenomena were obfuscated by the technological dimension of technoscience,[3] Hegel appreciated the hard, experimental work involved in moving from mere observation (the phenomenal) to genuine insight (grasping the noumenal, the inherent concept). Technoscience results from the dialectics of applied rationality and advanced technology, in the form of precision instruments.

[3] "Die Lehre von der Elektricität beinahe mehr eine Aufzählung der Maschinen und Instrumente, die man zu ihrem Behufe erfand, als eine Erklärung der Phänomene" (cited in Bachelard 1949/1962, p. 153).

It is a synthesis of the spirit of geometry and the spirit of finesses. Technoscience is the dialectics of master and disciple *in action*, with the disciple functioning as the servant or worker (the ego of science), while the master provides supervision (as the scientific super-ego). The dialectic of master and disciple often becomes reversed, however. In a laboratory, a young researcher can easily become the master of his master. Eventually, in technoscience, the noumenal is captured in symbolic terms, in terms of equations.

In *The Rational Activity of Contemporary Physics* (1951) Bachelard once again presents technoscience (in this case: contemporary physics) as an *active dialectic*, while Bachelard focusses on the role of technology in exploring the *dialectical interaction* between phenomenon and noumenon, between epistemological obstacles and methodological interventions. The wave-particle dispute in elementary particle physics is presented as an exemplification of such a dialectic, resulting in a comprehensive view in which both aspects are acknowledged as moments, in close connection with the insight that energy is fundamental for understanding matter in itself.

Finally, some new insights are added in *Rational Materialism* (1953), published in the year of the discovery of the structure of DNA, so that, not coincidentally, the transition from chemistry to biochemistry and molecular biology is discernible in Bachelard's book as well. The philosophy of technoscience, Bachelard argues, remains a *materialist* philosophy, but one whose understanding of matter is profoundly instructed by the results, the spirit of contemporary research. Chemistry is presented as a *dialectical* science (p. 6), as "*dialectical materialism*" even (p. 6). An epistemological rupture separates this radical (dialectical) philosophy from crude and metaphysical materialism, as defended by philosophical predecessors (from ancient atomism up to modern times). Moreover, technoscience is a collective endeavour. In technoscience, individualism became an obstacle, an anachronism.

Special attention is given to *practical* dialectics, notably metallurgy. Metallurgy, Bachelard explains, was an *active dialectic*, the first *dialectical materialist* technology in fact (p. 72), involving separation and recombination of metals, while purity was not the starting point (a given), but a result. Metallurgy entails a movement from primary substance (i.e. inchoate ore, M_1), via isolation and purification (M_2) up to synthetic recombination (M_3), where the latter can be considered as a rational form of creativity. Rather than dallying with abstract conceptions such as "substance", philosophers should devote more time to studying the novel questions emerging in technoscientific research. Notably Hegelian philosophers are addressed. They should examine the *dialectics* entailed in technoscientific practices, for instance practices involving technoscientific symbols and equations (p. 135). Together, philosophical and technoscientific approaches may result in a "dialectics of the electron", examining it from multiple (allegedly incompatible) perspectives, as a wave *and* as a particle, as a chemical *and* as a quantum physical phenomenon (p. 138), as a scientific *and* as a philosophical object.

Bachelard explicitly discusses the hydrogen bond (–H···), – which played such a crucial role in the discovery of the double helix –, as an example of a phenomenon which is to be studied dialectically, from multiple (contrasting) perspectives: by

questioning intermolecular bonding (quantum physics), intramolecular bonding (chemistry) and the molecular structure of proteins and other biomolecules (molecular biology). As a result of this displacement (from physics via chemical processes to the chemistry of life), experiences and insights which initially seem incompatible can be conjoined, while research into the role of the hydrogen bond in cell physiology becomes increasingly important. Indeed, we witness the emergence of molecular biology as a merger of quantum physics, biochemistry and cell biology (p. 140). And research into the hydrogen bond in molecular biology is not a mere "application", but a positive and synthetic research field in its own right. The hydrogen bond is an example of the kind of problematic which a new "phenomenology of the spirit" (in the Hegelian sense) should aim to address (p. 140). Indeed, the "spirit" at work in contemporary chemistry has important lessons for "Hegelianism", precisely because molecular biology is a "dialectical" science, outlining how the biomolecules of life result from a dialectical interaction, not only between energy and matter, but also between nucleobases and nucleic acids, with the hydrogen bond (–H···) acting as intermediary. Indeed, in terms of Hegelian dialectics, DNA is the outcome of a syllogism. The syllogism of electrophysiology as explained by Hegel (as an interaction between base and acid, with water acting as intermediary, and resulting in salt as product) resurges on the micro-level of biomolecular research (where nucleobases and nucleic acids produce DNA, with the hydrogen bond as intermediary). And this, Bachelard argues, calls for a meta-micro-physics (to replace traditional meta-physics).

The Year 1953

Although (to the best of my knowledge) Lacan nowhere explicitly refers to Bachelard, it is clear that Bachelard must be considered one of Lacan's key "precursors" (Eyers, 2012, p. 320), if only because Lacan shares Bachelard's emphasis on the importance of the "formation" of scientists (both rigid and practical) as well as his emphasis on the importance of formalisation and symbolisation (e.g. the use of mathematical, physical and chemical symbols as a decisive feature of technoscience). When Lacan speaks about the "formation of the individual" (1938/2001), he uses a phrase which echoes Bachelard's conceptions concerning the "formation" of the scientist. And when Lacan speaks about fire as the real ("le feu, c'est le réel", 1975–1976/2005, p. 121) we are reminded of Bachelard's *Psychoanalysis of Fire* (1938/1949) where he explains why fire as a primordial phenomenon no longer constitutes a valid object of technoscientific research. While fire (for instance: a hearth-fire) invokes multiple imaginary associations (childhood reminiscences, Hoffmannesque stories about alchemists in front of their furnaces, etc.), modern science relies on symbolisation (structural formula, chemical equations, and the like) to disclose the noumenal dimension of processes such as combustion and corrosion. As indicated, however, the question of this volume is not who influenced (or

polemicized with) whom. What is at stake is what we may learn from Bachelard's and Lacan's way of practicing psychoanalysis of technoscience.

1953 was a remarkable year for various reasons (Zwart 2020b). It was the year in which the second Kinsey report ("*Sexual Behaviour in the Human Female*") was published, the Mount Everest was conquered, and the first colour television went for sale. And it was also the year in which Michel Foucault awoke from his metaphysical slumber by reading Nietzsche. For technoscience, it was the year when Watson and Crick, building on the X-ray crystallography work by Rosalind Franklin and Maurice Wilkins, discovered the structure of DNA. Finally, it was the year in which Jacques Lacan presented his *Discourse de Rome* and launched his Seminar. DNA research and Lacanian psychoanalysis have something in common. Lacanian psychoanalysis used to be referred to as "structuralism", and although this label went out of fashion, the term indicated how (in linguistics for instance) combinations of elements convey meaning (information). In life sciences research, crystallography likewise reveals how all living substances are composed of biomolecular structures (crystals) and how these structures (the "forms" of living beings) convey information (Gilead, 2020). Structures are forms which *inform*, and crystallography is a basic technology for molecular biology, the biological version of "structuralism".

Jacques Lacan: Formalising the Hegelian Syllogism

Although the intellectual vocation of Jacques Lacan was to instigate a "return to Freud", Hegel's dialectics of master and servant may actually be regarded as the initial starting point of Lacan's intellectual trajectory. Indeed, both in his *Écrits* and in his *Seminars*, Lacan seems to serve two Master, both Freud and Hegel, although the latter sometimes speaks as a hidden Master's voice. Like in the case of Bachelard, I will explicitly zoom in on the dialectical dimension of Lacan's oeuvre: the continuities and differences between dialectics and psychanalysis.[4]

Lacan acknowledges his indebtedness to Hegel on multiple occasions, claiming for instance that it is impossible for psychoanalysis to ignore "the structuring moments of Hegel's phenomenology", e.g. the dialectic of master and servant, the figure of the beautiful soul and the interrelatedness between the constitution of the object and the formation of the subject (Lacan, 1966, p. 292). According to Lacan, a point of divergence between both approaches is that psychoanalysis aims to

[4] In their best-seller *Fashionable nonsense*, Sokal and Bricmont (1998) framed Lacan (together with many other, mostly Francophone authors) as an "intellectual imposture". Rather than entering into this (repetitive) debate myself, to which already a huge amount of literature has been devoted, I prefer to move beyond the "science war" polemics and to opt for a "positive" approach, by indicating how Lacan not only had a thorough grasp of what was happening in science, but also made important contributions to philosophical reflection on technoscientific developments. Overall, rather than entering into discussions (often quite polemical) with critics of continental philosophy, the objective of this volume is to show what a continental approach amounts to, and to outline what it has to offer (*via positiva*) for practicing philosophy of technoscience today.

decentre the subject from self-consciousness (p. 291), but one may question of course whether such a decentring of individual subjects vis-à-vis self-consciousness or spirit deviates that much from Hegel's own conception.

Lacan commented on the dialectics of master and servant on various occasions. Initially, the servant acknowledges the supremacy of the master. Instead of challenging the latter's authority, the servant willingly relinquishes his own autonomy, opting for an attitude of devotion and servitude. Following the intervention of the master, the servant is put to work, in the interest of the master. Rather than aspiring to become a master themselves, servants accept a subordinate position, seeing their dependency as a prerequisite for survival: as the servant is not an owner, and needs to earn a living.

The master owns the means of knowledge production and the power relationship between master and servant is mediated by technology. An interesting example of this is mentioned by Lacan in his *Écrits*, when he argues that contracts require a considerable level of precision when it comes to time management. Therefore, dialectically speaking, it is no coincidence that Christiaan Huygens invented his pendulum clock in 1656 (patenting it the following year), because this clock embodies the symbolisation of the temporal real by technoscience. From now on, it is possible to determine and define the working day independently from natural phenomena such as dawn and dusk: a form of "liberation", and an important turning point in the shift from quality (craftmanship) to quantity (machine-labour). Since then, Servants are put to work in a universe of discipline and precision (Lacan, 1966, p. 313). As Marx already pointed out, whereas in pre-modern rural villages the difference between day and night (between production and reproduction) had been a matter of custom, during the industrial revolution all natural boundaries were shattered and clock-time forced human subjects to negotiate, with "Talmudic acumen", the exact meaning of the signifiers "day" and "night" (Marx, 1867/1979, p. 294). The servant's servitude also produces a particular form of jouissance, however, handling the master's property, guarding the master's legacy, in an efficient manner. Yet, a dialectical dynamic was bound to unfold, eventually subverting the situation in the sense that the sway of the master becomes increasingly dependent on the work of the servants, while the latter become increasingly skilful. The servants know that the master is mortal, moreover, and while the clock is ticking, they only have to wait. Time is crucially important in technoscience, where time is often quantitatively represented by the horizontal axis of the coordinate system, invented by Descartes, – although when Descartes published his discourse on method (in 1637) it would take quite a while before the first reliable pendulums arrived (Lacan, 1954–1955/1978, p. 94, 343). This (the absence or presence of contrivances of exactness such as pendulums) defined the difference between Descartes' thought-experiments and the scientific experiments conducted by Huygens and Newton. Without exactitude, no exact science, and no machine labour.

In Lacan's oeuvre, the position of the master is indicated with the help of the Master signifier, positing the master as primal subject, the initiator of the process (S_1). While the Master, after a single powerful, decisive intervention, devotes himself to contemplation, his style of thinking contrasts with the type of knowledge

produced by servants: *know-how*, basically ("savoir-faire", Lacan, 1969–1970/1991, p. 21). The master (the gentleman-philosopher) is initially in control. He appropriates the servant's practical knowledge and transforms it into abstract knowledge (e.g. "pure", Euclidean geometry). The desire to acquire "pure" knowledge (cleansed of everything reminiscent of reality and application, of "dirty hands") is a typical phantasy of the privileged classes. Lacan points to the dialogue between Socrates and the slave Meno, where Socrates acts as a benevolent gentleman-teacher, granting the illiterate slave a crash course in Euclidean geometry, only to discover that the slave already *knows* his geometry, albeit in a practical, hands-on manner. The knowledge of the servant has been appropriated by the master, who transforms it into apodictic, deductive knowledge, and now purports to give it back "for free", in the form of education (Lacan, 1969–1970/1991, p. 22).

In the end, the practical knowledge of the servants will prove much more powerful and effective compared to the lofty contemplations of the master who, instead of really interacting with and transforming nature, develops a worldview, i.e. an imaginary vision of nature (e.g. the phantasy of a spherical, harmonious cosmos). Eventually, the supremacy of the master (S_1) will by subverted by the practical know-how of the servant (S_2), so that in the end S_2 will come to occupy (usurp) the position of the agent: the one who is in control. The power of the master is subverted.

The emancipation of the servants does not stop there, however. Instead of relying on the concepts coined by the master, servants explore and interact with nature more directly, with the help of technical contrivances. The master's apodictic views are suppressed, as former servants increasingly rely on hands-on, practical interactions with nature, developing powerful tools to effectively manipulate and modify natural objects: the birth of the experimental method. Exegesis increasingly gives way to experimental work (manipulating nature). Thus, former servants assume mastery over the situation. They become scientific agents, while the metaphysical pontifications of the master become a superfluous burden.

This is evidently in line with Hegelian dialectics. Initially, the Master is the primary *agent* (first position), spokesperson of a general, apparently neutral and stable worldview, while the servant is the *other* (second position), inciting the idle master into activity (disrupting his *otium*), but also the one to whom the master addresses his directives. In the course of history, the former servant inevitably emancipates into a qualified expert, so that the master becomes increasingly dependent on the know-how of the servant. Their interaction results in concrete *products*, which will initially be appropriated by the master. There is a fourth position involved, moreover: the *disavowed truth* of the master's discourse, namely the disconcerting experience that the Master himself is an alienated, doubting and divided subject as well (Hegel's unhappy consciousness). When this is recognised, the former servant emancipates by adopting (usurping) the position of the agent.

Lacan uses short-hand symbols to refer to these four variables: the master subject (S_1), the knowing servant (S_2), the divided subject ($\$$) and the object of desire (a). These four variables can be inserted into a quadrant, consisting of four positions (agent → other → product → truth), arranged within a quadruped scheme:

Agent	Other
(disavowed) Truth	(unintended by-) Product

Notice how closely Lacan follows Hegel's syllogism of agent (A), other (O) and product (P) (agent → other → product) that was discussed above (§ 2.12). Eventually, the dialectical process will reveal the (initially obfuscated) truth (T) of a particular constellation.

The interactions between these four variables, in four different positions, – albeit in a fixed sequence: agent → other → product → truth (AOPT) –, give rise to four "discourses".

Discourse of the Master

First of all, the discourse of the Master, already outlined above:

S_1 (A)	S_2 (O)
$ (T)	*a* (P)

Here, the master acts as *agent* (upper-left position), initiating the process and dominating the discourse. The master addresses the servant as the *other* (A → O). The servant is the recipient of the master's instructions, for instance by acting as a scribe or as an artisan (upper-right position). Although the master may have his moments of uncertainty and doubt, and will most likely be a desperate subject himself, this truth (*$*) is disavowed and obfuscated (pushed into the lower-left position) so that (formally at least) the authority of the master remains unquestioned. The servant produces the object *a* as product (P), but this object also indicates a loss, because it will be appropriated by the master, who will enjoy it, so that for the Servant, it is a "lost object", and the process of production has to be resumed to satisfy the demands of the master. The relationship between servant (S_2) and object (*a*) can be defined as "restrained desire" (desire kept in check: O → P). Although the servant's labour may be duly rewarded (in the form of a salary for instance, to earn a living), the surplus value as product (*a*) will be enjoyed and consumed by the master. Eventually, however, the servant will become aware of the master's dependency on his skills and products, and will realise that this is the obfuscated truth of the situation (P → T). This awareness, this consciousness, is the first step in the process of the servant's emancipation. In the end, the servants themselves will usurp the position of Agent (S_2 moving to the upper-left position), and the quadruped scheme will take an anti-clockwise quarter-turn to the left, resulting in a revolution, in the literal sense of the term. Thus, the master's discourse and its outcome is Lacan's equivalent of Hegel's dialectic of master and servant.

We may easily recognise a dialectical *syllogism* in this scheme. The process starts with the master as *agent* (M_1), allegedly an independent subject, fully in

control. The encounter with a submissive *other* (S_2), who subjects himself to the master in order to survive, to *earn a living*, gives rise to servitude as a particular form of interaction. For instance, the master may be in charge of a library, a scriptorium, a workshop designed for producing copies of authoritative documents, while S_2 may enter the situation as a novice, an anonymous scribe. The setting generates textual products, but although the scribes will be offered room and board (a living) for their efforts, the products (valuable copies) are appropriated by the master and accumulated in the library. Until the library is set to fire (as eventually happens to libraries, notably in times of revolution). Hume's advice, as a philosopher of Enlightenment, concerning the metaphysical volumes of the Master was: commit them to the flames, allegedly an act of cleansing and liberation (Zwart, 2019a, p. 68).

Thus, an antagonism is at work here, which will become increasingly evident. There is a hidden truth involved, the desire of the tormented master to remain in control of the situation and to appropriate the valuable outcomes of the process. Tensions will arise to the extent that the dexterity of the servant, in interpreting and reproducing authoritative documents for instance, is bound to progress in the course of time. The antagonism (the truth of the situation) eventually manifests itself, so that the syllogism fails to reach its proper end, giving rise to multiple obstacles and symptoms. As Bachelard already explained, in the context of intellectual collaboration, disciples may eventually become masters, in view of their dexterity and craftmanship, giving rise to disputes over authorship or intellectual property rights. Dissatisfaction with this type of discourse eventually results in the emancipation of the former servant, who now claims his intellectual independence and aspires to become the agent (A).

The predicaments of the servant are exemplified by Erasmus of Rotterdam as a case history. Evidently, he was not a mere scribe (copying documents in a more or less mechanical fashion) but a paragon of classical scholarship, preparing critical editions on the basis of his superb mastery of Latin and Greek. Yet, to realise his humanist scholarly idea, he still needed a technological base: the early modern printing press, as a replacement of the medieval scriptorium. In the case of Erasmus, this material base was provided by the printing house owned by Johann Froben of Basel, where Erasmus actually lived for many years, in close proximity to the process of printing the works he wrote or edited. As Lacan convincingly argued, the constitution and reformation of the early modern subject depended on the correctness and proliferation of the signifier. It was by modifying the relation to the signifier – e.g. by optimizing the procedures of exegesis and editing – that the moorings of the human condition were altered (Lacan, 1966, p. 527). But the signifier needed to be a reliable, i.e. *printed* one, edited by qualified scholarly experts, and printed by professional artisans.

Eventually, this dialectical process of emancipation gave rise to what came to be known as the scientific revolution. Until then, servants (scribes like, say, Thomas a Kempis) had obliterated themselves by devoting their time to reading, copying, editing and commenting authoritative texts (e.g. the Bible, Church Fathers, etc.), or documents written by Master thinkers (a position which, in medieval scholarship had been allotted primarily to Aristotle). Now, however, the former servants decided

to study and interact with their object of research more directly. Rather than commenting on the Scriptures or on Aristotle's *Physics*, the ambition now becomes to engage in technoscientific research oneself. Research contrivances (scientific instruments) replace the master as intermediary between subject and object. This does not mean that the researcher at work is now fully independent, quite the contrary. Intricate machinery is required to come to terms with the elusive objects of research. Research requires a material base and instruments have to be funded.

A fascinating early modern example was already described in the previous chapter: Tycho Brahe's astronomical observatory Uraniborg. Brahe decision to focus on astronomy had been triggered by the sudden emergence of an "impossible object" (*a*), a *nova stella*, an oxymoron in a world where celestial bodies represented unchanging eternity. Brahe's "impossible" *object a* provided a window (an opening) into the enigmas of the starry universe. Brahe's ambitious and extremely expensive Uraniborg-project was completed in 1580 and sponsored by King Frederick II of Denmark (the monarch, acting as master). During the early-modern period, absolutist monarchs often functioned as funders of research. Thus, the researcher was working for a master. A dialectical view on the history of technoscience zooms in on what, in normal discourse, revolving around scientific heroes and their ideas and intentions, tends to be obfuscated: the power relationships to which these egos of science are actually subjected: the relationship between knowledge, power and desire. In the case of Tyche Brahe, much time and energy were spent on prognostications, using celestial harmony to seek for guidance in tumultuous times (Pannekoek, 1951/1961). These prognostications were comparable perhaps to how nowadays politicians consult the Wall Street stock exchange before making difficult decisions. The observatory functioned as a kind of eye which allowed only small, quantifiable samples of reality to enter. The products of this dialectical interaction reflect the antagonisms at work: Europe's most advanced and expensive observatory, manned by the last of the naked-eye astronomers, who published a drastically renovated astronomy in combination with prognostications, in short: Tycho Brahe as a divide subject, mid-way scientific revolution and servitude.

S_2 (Tycho Brahe as ego of science, as homunculus inside his observatory) as agent: A	*a* (the impossible object or oxymoron, *nova stella*) as other: O
S_1 (Supported by King Frederick II, the absolutist monarch); servitude to the Master's worldview as (disavowed) truth: T	*$* (Tycho Brahe as a divided subject; unintended by-product): P

All this is part of the early modern history of technoscience, however. Let us now, after these concise historical detours, return to psychoanalysis, that is: to the moment when psychoanalysis was born, during the 1890s, when the former servants had fully emancipated and university discourse was allegedly in full swing, exemplified by physiology as a research field (Freud's initial field of training).

The Emancipation of S_2 – The Case History of Ivan Pavlov

In the nineteenth century, funding of research had become a responsibility of the state. In the course of the scientific revolution, the syllogism of the knowledge production had given way to what Lacan refers to as university discourse:

S_2	*a*
S_1	*$*

The experimental expert (S_2) is now the *agent*, taking the initiative, initiating the process, relying on technical dexterity and expertise, designing and conducting experiments directed at addressing, questioning and capturing the object *a* (now in the position of *Other*) without any direct interventions from a Master. S_2 does not refer to *one particular* technoscientific brain worker, for research will often be conducted by teams, involving multiple trained experts, working together on the basis of division of labour. S_2 may be the head of a laboratory, but research managers are not Master in the Lacanian sense. They are qualified researchers, supervising other researchers, so that both research managers and their junior researchers find themselves in a precarious position as brain workers, the latter because junior researchers tend to be employed on the basis of temporary contracts, the former because the fate of the manager will depend on the performance of the laboratory as such (where clocks are always ticking).

Ivan Pavlov many perhaps serve as a telling exemplification of the new situation (Zwart, 2010). In four successive years (1901, 1902, 1903, 1904) Pavlov was nominated for the Nobel Prize in physiology or medicine, and each time the award committee confronted the same question: to what extent were the products of Pavlov's laboratory truly Pavlov's? The nominee had himself pronounced that his work was the achievement of his laboratory, operating as a knowledge factory. He had credited his co-workers for actually conducting the experiments on which his output was based. Did Pavlov's work represent his own original contributions to science, or was it merely a compilation of experimental dissertations (Todes, 2002, xiii)? Pavlov was a research manager rather than a solitary researcher, and his laboratory was a factory producing knowledge claims in a systematic fashion, a knowledge production line (Todes, 2014). Although Pavlov designed most of the trials and collected the research results to present them in books, papers and lectures, the actual experiments were conducted by "praktikanti" working in Pavlov's research facilities, hoping to complete their medical training in this manner. The interaction between supervisor and praktikanti resulted in numerous products, boosting the laboratory's reputation. In 1904, the Nobel Prize finally was awarded.

Jacques Lacan was interested in the case of Pavlov (a contemporary of Freud) for various reasons (Zwart 2018b, 2019a). Whereas ethologists describe animal behaviour in terms of response triggered by visual stimuli (the gestalt of a predator, a prey, etc.), Pavlov's research demonstrated how animals may function in a symbolic environment, where artificial signs trigger the production of bodily fluids. It is no

coincidence therefore that Pavlov acknowledged the contributions made by his compliant dogs in his publications. Research implied intense collaboration, not only with praktikanti, but also with these animals. As Haraway (2008) convincingly argues, besides research assistants and animal caretakers, also the research animals themselves were "workers in the lab" (p. 71, 73). Both the people and their dogs laboured to produce knowledge under strained conditions. Rather than mere objects, they were partners in the research.

Whereas the qualified researchers conducted the experiment, the bodily fluids excreted by animals (saliva and gastric juice, produced in response to signals) functioned as object *a*. Pavlov made small openings (windows or fistulas) in the throat or stomachs of his animals to collects these secretions, so as to measure and analyse the samples as exactly as possible. Thus, saliva and gastric juice (slimy substances, regarded as detestable in normal life) became highly valuable entities, *products* produced by the animal-*other*. Although allegedly both humans and dogs participated voluntarily in the research, praktikanti were required to participate as a mandatory internship, while animal suffering was often involved. Ideally, animal laboratories are perfectly organised settings which satisfy all animal needs, thereby reflecting a modernistic, utopian ideal (Lacan, 1957–1958/1998, p. 461), a brave new world, a *Walden Two*, perfectly managed with the help of science and technology (1957–1958/1998, p. 463). This explains why the communist leadership (both Lenin and Trotsky) were firmly supportive of Pavlov's work: they saw his laboratory as a window into the future and as a model version of a future communist society. In reality, however, Pavlov's laboratory was not that animal-friendly at all. It produced animal suffering in various forms (as unintended by-product of the research), resulting in various kinds of symptoms (*$* as product). Pavlov even noticed "experimental neurosis" among his dogs (Lacan, 1966, p. 273; 1962–1963/2004, p. 72). His lab was a pathogenic environment, a totalitarian regime that cared for its animals but exploited their bodies as production factors, while eventually it was the research manager (S_2) who enjoyed the fruits of the dogs' labour, in the form of publishable and citable knowledge and, eventually, the Nobel Prize (the ultimate object *a*, awarded by the committee as "other", as forum, as final recipient of Pavlov's output). This entailed a process of displacement ("*Verschiebung*"), of denaturalisation and symbolisation (from fluids via publications to recognition).

The laboratory was a knowledge factory driven by desire, by a will to know, but also by a will to power, a desire to acquire behavioural control (Lacan, 1964/1973, p. 264; cf. Zwart, 2014): the truth of the constellation. In October 1919, Lenin allegedly paid a secret visit to Pavlov's laboratory to find out how the work on conditional reflexes might help communism to control human behaviour. The ultimate aim of communism was to improve and transform human nature. Although Pavlov was critical of communism, he accepted patronage by the Bolshevik regime. Lenin spoke of Pavlov's work as hugely significant for the revolution and Trotsky saw the production of an improved version of humankind as communism's great task, using current humanity as raw material. Pavlovian psychology became official doctrine and in 1949 it was formally declared that Pavlov had demolished "the Freudian house of cards" (Roudinesco, 1986, p. 53). On January 24, 1921, a formal Decree

was published on Pavlov's research (Lenin, 1921/1965, p. 69), indicating that, in view of Pavlov's outstanding scientific services, which were of tremendous importance to the working people of the world, a special committee was established to guarantee the best conditions for his research. While his laboratory would be furnished with every possible facility, Pavlov and his wife would receive a special food ration (twice the number of calories of normal academic rations). Pavlov himself was thus addressed and treated as an experimental dog by the communist leadership, encouraging him to continue to produce knowledge. A specific signifier (the formally signed decree) was installed, signifying food (during a period of massive deprivation and starvation). Thus, a specific form of scientific work was singled out as being of strategic importance. Although the voice of totalitarian power (S_1) spoke from beneath the bar as it were, university discourse continued to function. In the case of Pavlov, the distance between S_1 and S_2 was maintained. Surveillance by Lenin and Trotsky operated from a distance, without direct interference in the experiments. In the case of Stalin, Žižek argues (2016/2019, p. 254), the proper dialectical tension between S_1 and S_2 collapsed – as exemplified by the Lysenko case.

University Discourse and Its Vicissitudes

This is how Lacan sees university discourse, a form of discourse which is not only found at universities, but has a much broader range of applications, for instance to explain the functioning of modern bureaucracies. The science manager (S_2) is focussed on things like quality indicators and impact scores (as object *a*), but these may become "perverse incentives", resulting in symptoms such as discontent or burn-out among exploited brain workers (*$* as unintended by-product). Lacan defines communism as a form of university discourse operating on the level of the state. Currently, it is often claimed that, in the era of globalisation, all the world is becoming a laboratory: a global living lab, while all individuals function as research subjects, constantly producing data, – which basically means that the syllogism of university discourse has dramatically proliferated, has acquired an astonishing external validity.

S_2	*a*
S_1	*$*

The qualified expert or brain worker (S_2) is the agent, taking the initiative, designing and conducting the experiments, while outsourcing most of the activities – the actual experimental being-at-work of technoscience – to intelligent machines. This not only involves routine and menial activities, for contemporary technoscience relies on molecular precision and advanced computation, enabling us to gain access to weird, noumenal domains which are not part of human reality, from quantum oscillations to the genome, outside the human sensorium, existing independent from

human consciousness, a nonhuman real which is not part of our reality (Žižek, 2016/2019, p. 33). Apparatuses enable humans to explore the real outside the scope of their experiential reality. The object *a* is now a weird, freak object, preferably on the molecular scale. Many servants may actually function as managers, principal investigators or departments heads, but as indicated, these managers are not Masters. Managers are workers, perhaps even workaholics, whose activity is driven by struggle for survival, – the pendulum is watching them. Their position may actually be quite precarious and the end of their career may always seem imminent, for instance in the case of disappointing results (a fall in the rankings). The Master is an invisible Master, pushed beneath the bar, but still quite persuasive (e.g. Lenin and Trotsky supporting Pavlov's work as a reinforcement of soviet ideology). In contemporary technoscience, the Master may operate as a hidden, anonymous Über-Ich, a relentless imperative (go on, produce more knowledge, never enough!), never satisfied with the performances of research managers and their teams, confronting them with a digital pendulum, a stock market of global research performance indicators, using advanced search robots to take count of all publications and citations, relentlessly pushing brain workers to produce more data, more papers, more results. Interestingly, funding agencies and university boards are currently becoming aware of the extent to which performance indicators such as *h*-scores may operate as perverse incentives, meaning that research activities become focussed on boosting rankings (e.g. of journals and universities) rather than on the "societal relevance" of the knowledge thus produced. But this will probably neither end the quest for comparative (competitive) metrics nor the hyperactivity of technoscience as a global enterprise. Metrices for "impact" and "diversity" are already proliferating.

Thus, like all four discourses, university discourse constitutes a syllogism, in the Hegelian sense of the term (from *agent* via *other* to *product*). The *agent* (the qualified expert: S_2) is challenged by and manipulates (challenges) *otherness* (i.e. the enigmatic object of research: *a*), and this process may result in various products, first and foremost in research papers: an anonymous type of output where a technical, anonymous form of authorship effectively results in the marginalisation of the subject (the "death" of the author). In university discourse, "it" speaks. As Nietzsche already argued, modern science entails the replacement of exceptional geniuses by armies of anonymous individuals (1980, § 547; Zwart, 2010). According to Nietzsche, a true scientist will endorse rather than deplore this anonymity as inevitable. For Nietzsche, a true scientist is not only someone who is willing to put his theories to the test, remaining susceptible to criticism, continuously on the alert not to deceive himself; for Nietzsche, the most important scientific virtue of all is self-denial. *Was liegt an mir!* It is not me that counts! For Nietzsche, this phrase summarises the core of the scientific ethos, the quintessence of being "in science" (1980, § 547).

His view was taken up many years later by Michel Foucault: "Qu'importe qui parle?" For Foucault, the most fundamental ethical principle of contemporary scientific discourse resides in a basic indifference towards authorship (1994, 789; Cf. Zwart, 2001). Science is, first and foremost, a discursive phenomenon in which

author names serve as functional tools, notably in the context of information retrieval and quality assessment of research teams. In normal science, academic authorship comes very close to anonymity, and there is a certain moral quality in the stoical acceptance of this fact. Thus, rather than serving as a medium for self-expression, academic output entails de-subjectivation and alienation, until (in the extreme sense) the subject is reduced to something purely symbolic, an *h*-score for instance or an ORCID (a persistent digital identifier). This alienation or division (*$*) between the formal subject (e.g. the researcher as a kenotic cogito, stripped of all subjective content) and the actual, living, tormented subject (the researcher "as a person", desperately struggling to keep up with the academic pendulum), is an inevitable outcome or *product* of university discourse. The same alienation can be encountered in bureaucratic systems, as reflected in the impersonality of letters and reports written by civil servants (or their robots).

Experts as agents (S_2) realise their grounding conception through their work. Erring consciousness desires to become science. Initially, human beings are split, barred or erratic subjects (*$*), characterised by a propensity to err, to go astray ("Irre", in Hegel's terms, 1807/1986, p. 106), indicating that individuation, although aimed at reconciliation and realisation, remains a hazardous and interminable process. Knowledge production offers erring subjects a "ladder" (Hegel, 1807/1986, p. 29) to reach the standpoint of science, temporarily allowing them to function consistently, as subjects or egos of science ($\$ \rightarrow S_2$), as reliable producers of replicable knowledge. Desire is temporarily kept in cheque, and S_2 no longer experience themselves as tormented subjects. Yet, as indicated by the matheme or syllogism of university discourse, the end result is nonetheless a resurgence of despair (*$* in the lower-right position). Notwithstanding the subject's hard work, the gap between truth and knowledge resurges, and the split recurs as an irreconcilable scar. The truth of university discourse is that a hidden metaphysical imperative (S_1) was pressing the subject towards verification, a process which eventually falters. The subjects experience the deficits and one-sidedness of the concepts they aspired to realise. Their insight was a mere moment in the history of knowledge, about to be superseded.

Thus, the place of truth (lower-left position) must likewise be understood in Hegelian terms, namely in the sense that a particular figure is the truth of another, preceding figure, and the exposition of its concealed latent structure (Žižek, 2016/2019, p. 217). University discourse is the inevitable successor of the discourse of the Master, because in the course of history, qualified expertise inevitably replaces reliance on authoritative documents (Aristotle, Genesis). Primal insights have to be verified through empirical labour and working-through ("hindurcharbeiten", Hegel, 1807/1986, p. 31), and thinking subjects must discern their guiding idea in what apparently refutes it, must absorb apparent otherness into the expanding system of science. At the same time, the spectral position of the Master remains the disavowed truth of university discourse: the apparently neutral position of qualified expertise (S_2) conceals a dimension of domination, a will to power, so that S_1 in the lower-left position refers to the hidden metaphysics at work, which must be brought to the fore and questioned. Otherwise, as Hegel argued, it will dominate us.

Within the constraints of university discourse, we can never completely rid ourselves of this hidden Master, this vocal spectre, except perhaps through elimination, but to do so we may have to sacrifice our own scientific career (accept that our existence as a *homo academicus* may be terminated). As long as we remain in science, in the field, the imperative remains in place. In other words, after the scientific revolution, brainworkers for whom the pendulum tolls are working harder than pre-revolutionary scholars who were serving a monarch. As Bachelard already argued, the scientific method is closely connected with surveillance. Performance indicators are reifications of the academic super-ego, precision instruments of supervision, a panopticon watching us (technoscience as a race against the clock, a relentless struggle for priority).

Thus, Lacan's scheme concurs with the schema provided by Hegel in the *Phenomenology of the Spirit*, situating subjects in their relationship to knowledge (Lacan, 1966, p. 793). The scheme positions the scientist as a subject (p. 794), indicating that science did not come into this world all by itself, but as a result of a scientific revolution, defined as an anti-clockwise quarter-turn of the quadruped scheme. According to Lacan, one important difference between dialectics and psychoanalysis (between Hegel and Freud) is that Hegel failed to acknowledge the importance of machines (1954–1955/1978, p. 94), but this is a questionable claim. Obviously, there can be no mechanics without machines (e.g. pendulums) and no chemism without machines, no electrolysis without technical contrivances, resulting in batteries and so on. Although Hegel's logic is about ideas rather than machines, developing a dialectics of technoscience is the inevitable next step as we have seen (Juchniewicz 2018), so that dialectics becomes sublated into *dialectical materialism*, as Bachelard argued, because that is what the inherent philosophy of technoscience essentially is: dialectical materialism. Still, precisely to bring this to the fore, dialectics and psychoanalysis complement one another.

In short, in university discourse, the intentionality of S_2 is focussed on *a*, endeavouring to integrate (process, domesticate, appropriate) this enigmatic, recalcitrant entity. This is in accordance with Marx's view of technoscience as the appropriation ("*Aneignung*") and transformation ("*Verarbeitung*") of the real. The "unique selling point" of experimental technoscience is precisely its focus on a particular (recalcitrant, enigmatic) entity, something surreal, a sur-object (Bachelard) rather than an object, a non-substantial entity eluding the subject, never really there, a stain-like form which, like in the case of anamorphosis, can only be made visible when looked at from a particular (technologically mediated) perspective (Žižek, 2016/2019, p. 83). Speaking from beneath the bar (from beneath the stage) is the normative imperative: go on, produce more knowledge, never enough! The activity (energeia) of technoscience is sustained by normative pressure.

A First Case History: The Majorana Particle

Allow me to elucidate this scheme with the help of a first case study. In particle physics, every type of particle is associated with an antiparticle, with the same mass but with opposite physical charge (so that electrons are associated with positrons, etc.): an intriguing exemplification of Hegel's view on polarity in nature, as discussed above. Particles and antiparticles annihilate each other, producing photons as a result. Some particles are their own antiparticle, however, and this applies to Majorana fermions of Majorana particles, whose existence was hypothesised by the Italian physicist Ettore Majorana in 1937. Majorana particles became the focus of intense interest because they may serve as building blocks (as stable, error-proof "qubits") for quantum computing. After predicting their existence, Ettore Majorana mysteriously disappeared in 1938. He left a note saying that he made a decision that had become unavoidable. He may have committed suicide, but his body has never been found and it has also been suggested (by novelist Leonardo Sciascia, among others) that, being a devout catholic, he may have decided to become a monk.

So far, Majorana particles remained enigmatic entities, but recently, research groups claimed to have observed "signatures" of these exotic objects (Zhang et al., 2018; Manna et al., 2020). The publication by Zhang et al. in *Nature* was heralded as the "third step" in a Majorana trilogy: from the prediction by Ettore Majorana in 1937, via the group's disappointed first efforts at confirmation, up to the final publication, presented as "definite proof" of the particle's existence.[5] Allegedly, this experiment closed the first chapter in the quest for Majorana particles, and opened the way to the next chapter: working towards quantum information processing based on their unique properties.

Recently, however, the research group involved, led by Leo Kouwenhoven at TU Delft, indicated its growing doubts and concerns as to the validity of their previously published results, while an integrity committee is now investigating whether the research was conducted in accordance with appropriate standards.[6] Obviously, besides scientific prestige, substantial financial interests are at stake, as quantum computing is heralded as the next era in computing. Although no further details were provided, the authors apparently alerted the editors of *Nature* to potential problems in the manner in which the data had been processed, affecting the reliability of the conclusions that had been drawn (Zhang et al., 2020). Ongoing investigations remain confidential until their completion.

This case history concurs with the syllogism of university discourse. S_2 (here represented by a prominent and highly esteemed research group) becomes intrigued (or even obsessed) with an enigmatic entity (the object *a* of particle physics) whose ontological status remains highly uncertain. Majorana research counts as high risk research. It can lead to everlasting fame, but also to disaster. The syllogism can be

[5] https://eurekalert.org/pub_releases/2018-03/duot-mtc032318.php

[6] https://qutech.nl/2020/05/16/expression-of-concern-about-quantized-majorana-conductance-publication/

summarised as follows: a prominent research group (S_2) acquires international fame by announcing a breakthrough concerning research which seems as hazardous as it is inexorable and enticing. The forbidding Majorana particle is an alluring actant, inevitably drawing prominent research groups onto hazardous terrain. Besides academic prestige, enormous financial prospects are beckoning. Thus, the researchers fall victim to their *cupido sciendi*, their will to capture the allusive object (*a*). By giving in to their desire, they become divided subjects (*$*), caught in the tension between methodological prudence and scientific carefulness on the one hand, and the benefits of priority in research on the other (including the Nobel Prize). This dynamic is captured by the matheme of desire ($\$ \diamondsuit a$), where $\diamondsuit$ represents the high-tech contrivances that allow researchers to zoom in on their sub-atomic target, while haste, carelessness or even misconduct are the by-products, the symptoms (emerging in the lower-right position). The first author (Hao Zhang) is now under the suspicion of being a tormented subject who resorted to fraud.

The truth of the constellation is that research, rather than being pure and disinterested, is driven (contaminated) by desire. Ettore Majorana himself was the first victim of the particle he predicted. His breakthrough resulted in an impossible situation, which either resulted in suicide, or in a decision to revert to servitude (S_2 becoming monk, a servant, functioning in service of the Master signifier, the Word of God). In other words, the two version of his death are quite dissimilar. In the case of suicide, his despair (*$* in the lower-right position) would have been pushed to the extreme, but in the case of conversion, S_1 would have been elevated ("*aufgehoben*") into the position of the agent, and the quadruped scheme would have taken a clockwise quarter-turn to the right. Ettore would have remained S_2, but now in the upper-right position of the servant, the one who is being called, the one who is addressed.

Bringing the inherent antagonisms and inconsistencies of university discourse to the fore, by questioning its inherent metaphysics for instance, requires a different discourse, however, another anti-clockwise turn of the quadruped scheme, towards the discourse of the analysist, resulting in an oblique perspective on technoscience. Here the focus is on the object of desire (*a*), which is now seen as an actant, initiating the process, becoming an obsession.

Discourse of the Analyst

Although philosophy of technoscience is an academic practice, it entails a change of perspective compared to normal "university discourse" as defined by Lacan. Practicing philosophy of technoscience means adopting an oblique perspective, titling the "normal" stance. Technoscience entails an *intentio recta* as we have seen, addressing the object directly, albeit with the help of technology, enabling us to zoom in on partial objects. Philosophy of technoscience, however, entails an anti-clockwise quarter-turn:

a	*$*
S_2	S_1

The expertise of the technoscientific expert is suspended (pushed beneath the bar) so that the interaction between the divided subject (*$*) and the enigmatic object (*a*) comes into full view. Now, the subject is no longer regarded as a (kenotic) qualified technoscientific expert, the cogito of technoscience (S_2), but rather as a tormented subject driven by desire (*$*): the desire to know (*cupido sciendi*), obsessed by a weird, impossible object, referred to by Lacan as object *a*, something which resists symbolisation (which resists incorporation into the body of accepted knowledge) and whose ontological status is highly precarious, something which cannot be seen or grasped directly: an invisible factor X, a hidden cause, an incarnation of a void, something which may only be visible as a stain or signature on a surface, or as a trace in a cloud chamber, or as a biomolecular entity projected on a computer screen. Psychoanalytically speaking, a technoscientific expert (*$*) is a pervert, obsessed with a questionable (perhaps even dangerous) entity: say, a tumour in the abdomen of a nude mouse, or the element radium (both toxic and enigmatic), or the gynosome of a "phallic" female Brazilian insect. This obsession is legitimised retroactively, however, in the form of highly-cited research papers, comparable to how the perversion of an artist (say, Baudelaire's vampirism, his biting compulsion) was sanctioned by sublating it into sublime poetry. As technoscience entails the symbolisation or appropriation of the real, however, in the case of technoscience, the product of the interaction between researcher and research object must be something even more symbolic than a poem: a research paper, or a series of publications, or eventually something like a *h*-index (indicating a research program's market value).

CRISPR-Cas9 may serve as an example here. In her autobiography Jennifer Doudna (Doudna & Sternberg, 2017) tells the story of her meeting with Emmanuelle Charpentier in a café in Puerto Rico in 2011, where they decide to coagulate two enigmatic entities, namely CRISPR (DNA sequences in bacteria derived from DNA fragments of viruses that previously infected them) and a mysterious enzyme, a molecular scissor named Csn1 (later rebaptized Cas9) to produce a molecular, high-precision genome-editing machine: a decision which eventually resulted in a "tsunami" of citations. Human agency is questioned in Doudna's autobiography (Zwart, 2019b, p. 69), as CRISPR and Cas9 seemed to have a life of their own, as actants, using hardworking researchers as vectors to coalesce and proliferate.

Evidently, the discourse of the analyst has its deficits as well, such as lack of scientific status (as S_2 is suspended, pushed beneath the bar; Lacan, 1966, p. 794), so that others (S_2) may question whether philosophers are *qualified* to proceed along this path of assessing technoscience. This is the difference between university discourse (where qualified subjects – S_2 – take the floor), and the discourse of the philosopher / analyst, even if the philosopher builds on dialectical experience and established a "track record" for being in science.

Language and the Tormented Subject ($)

Compared to Bachelard, Lacan's focus on "discourse" emphasises the importance of language and the linguistic aspects of technoscience. In order to come to terms with technoscience, we must first and foremost pay due attention to the signifiers used. Language is not an indifferent medium, but always already traversed by antagonisms. Language brutally destabilises our being-in-the-world. Human discourse not only *expresses* psychic turmoil: our entry into the "torture house of language" is itself a traumatic act (Žižek, 2016/2019).

For Lacan (who grew up in a Catholic cultural ambiance) the phrase *In the beginning was the Word* constitutes the starting point for coming to terms with technoscience (Lacan, 1960/1974/2005, p. 89; cf. Lacan, 1960–1961/1991, p. 12). Humans are speaking beings, called upon by language, by the commanding word, the discourse of the Other: the symbolic order which, for humans, is always already there. What is unique about humans is neither their intelligence, nor their convoluted brain, Lacan argues, but first and foremost their openness to language. If I.Q. would be the decisive issue, human intelligence (as the outcome of Darwinian evolution) would have been up to its tasks, allowing us to smoothly adapt ourselves to our environment (cf. 1963/2005, p. 72). But in humans we see a chronic *failure* to adapt, a discord between desire and environment (Chiesa, 2009). It is precisely here, in human discontent, that language intervenes. Language has a disruptive impact on human existence. We are *speaking* animals, liberated from nature, but burdened by language, even sick with language (Lacan, 1960/1974/2005, p. 90, p. 93; Cf. 1961–1962, p. 42).

Due to language, and other dimensions of human culture building on it, notably technoscience, a decisive rupture separates human existence from the natural (pre-symbolic) mammalian world. According to Lacan, without language humans would be happy animals thriving in a natural Umwelt, where visual cues (described by ethologists in terms of *stimulus* and *gestalt*) would unleash pre-established physiological mechanisms (1953/2005, p. 20) as pre-programmed behavioural responses (fight, flight, freeze, arousal, etc.). As animals, humans would dwell in an ambiance of visual gestalt-like stimuli, referred to by Lacan as "the imaginary": basic sets of images, and the repertoire of typical responses triggered by them. But the human world is replete with and disrupted by "the symbolic": norms and expectations, numerical and linguistic information, giving rise to a supra-personal "symbolic order". And it is only because of the symbolic order that technoscience exists: allowing us to come to terms with the Real with the help of a terminological grid of technical terms and other symbolic ingredients (numbers, formulae, measurements, mathematical and chemical symbols, acronyms, equations, computer programs and the like).

For Lacan, technoscientific research entails a process of "symbolisation", transforming geosphere and biosphere with the help of "characters". In ancient Greek, στοιχεῖα (elements) refers to elementary building blocks (of reality or knowledge), but first and foremost to the characters of the alphabet (employed both as letters and

as numbers), and this applies to modern technoscience as well. According to Lacan, technoscience is the systematic effort to disclose the basic constituents of nature with the help of symbols: Arabic numbers, alphabetic letters, mathematical symbols, chemical formulae, proliferating acronyms, and so on. These numerical or letter-like (typographical) symbols are the "elements", the symbolic "atoms" by means of which science operates (1960/1974/2005 p. 23, p. 50). Thus, whereas the pre-scientific world of everyday experience continues to rely to a significant extent on images (visible entities, world views, body images, self-images, metaphors, anthropomorphic interpretations, and the like), technoscience develops contrivances (measuring instruments, experimental equipment, etc.) which replace these imaginary, gestalt-like items with standardised terms, numbers, digital data and equations. Molecular genetics, for instance, aims to *see through* the living organism (the visible Gestalt, say: a malaria mosquito) in order to *read* the symbols (the "characters") within: the genotype in the literal sense of "type" (Zwart, 2016). Insofar as science produces images, they are highly technological, such as crystallographic X-ray pictures of DNA: visualised quantifications (Lacan, 1961–1962, p. 42). The symbolisation process gives rise to a terminological grid of signifiers and quantitative numerical data. This means that the technoscientific universe is a radically "inhuman" world (1960/1974/2005, p. 49). Technoscience abstains from anthropomorphism (the tendency to interpret the world from a decidedly *human* viewpoint, p. 50).

Via technoscientific symbolisation, the biosphere is incorporated into the symbolic order as a web of terms, contrivances, machines, networks and the like. Ultimately, the tendency towards symbolisation results in a "literation" (or even *ob*literation) of life (Zwart, 2016). Rather than observing and interacting with (fleshy, messy) *living* beings, molecular biologists prefer to view life as something symbolic: nucleotide code. Although this process may seem to proceed in a smooth and automated manner, it is hampered or disrupted by the recalcitrance of the Real, when symbolisation falters and fails to work (Lacan, 1960/1974/2005, p. 76). The symbolisation or "literation" of the Real gives rise to various by-products in the form of *litter* (including data litter), as technoscience allows humans not only to hominize but also to dramatically *pollute* the world. Think of plastic litter that currently litters not only terrestrial environments but also littoral areas and oceans: plastic packaging, carrying letters – the logos of their producers, left-overs of human λόγος (Zwart, 2015).

Lacan sees humans not as privileged beings (who *have* something which other animals *lack*: big brains, self-consciousness, intelligence, etc.), but as stunted and frustrated subjects, discontent in their socio-technological environment, unable to live up to what is expected of them. Lured and fascinated by the imaginary (erratic longings, erotic phantasies, political utopias, etc.) they are at the same time tormented by norms, commandments and injunctions (e.g. the impossible but highly persuasive injunction of neo-liberal culture to *enjoy* life to the full).

Lacan is especially intrigued by contemporary discontent with technological advances, by human ambivalence triggered by the unstoppable explosion of knowledge production, providing us with a disquieting power over the elementary

particles of life and nature (1969–1970/1991, p. 120). While we finally seem able to gratify our desires, we are paralysed by uneasiness and technophobia. In terms of the four discourse, discontent gives rise to the hysteric's discourse:

$	S_1
a	S_2

In this type of discourse, the tormented, discontented subject takes the floor (*$*) as an agent for whom technoscience is a powerhouse generating questionable top-down authoritative statements (S_1), concerning the safety of GMO food and vaccines for instance, or the necessity of lock-down measures to contain the COVID-19 pandemic. From an oblique perspective, this discourse must be assessed in a symptomatic manner, focussing on its "truth", its object of desire (*a*). What is it these protesters *really* want or fear? What do they mean by *natural* food (versus GMO food), or by *natural* resistance (versus vaccine-induced resistance), for instance? Probably, they see technoscientific items as components of (and as contaminated by) the system which generated the crisis in the first place. Rather than discarding such voices of protest as "irrational", we must look for the kernel of truth (the "moment of truth", as Hegel phrased it). Besides "hysterical" agents (*$*) and "authoritative" others (S_1), a *product* is involved in this syllogism as well, as technophobia may give rise to new and valid research questions: qualified experts translating societal discontent into "reasonable concerns" (biohazards, health risks, double use, etc.) that can and should be addressed (S_2). From the viewpoint of the tormented subject, however, such translations evidently miss the point. Such mitigating research endeavours cannot compensate the loss of an (imaginary) pastoral world of natural (artisanal) beverages or food items (*a*).

Discontent in technoscience may also arise *inside* the system. One noteworthy symptom, Lacan argues – speaking in 1974, during the heydays of recombinant DNA research, when Nobel Prize laureate Paul Berg published his famous letter in *Science* on "biohazards" of technoscience (Berg et al., 1974) –, is that scientific research itself becomes an "impossible profession" (1960/1974/2005, p. 73; cf. Freud, 1925/1948, 1937/1950). Researchers face a paralysing "crisis of anxiety" (1960/1974/2005, p. 74). While scientists tamper with potentially dangerous bacterial strains in their laboratories, both lay audiences and the experts themselves are alarmed by the idea that these microbes may one day escape from the laboratory, causing pandemics in the outside world (1960/1974/2005, p. 74), perhaps even cleansing the world from human beings; – these unflagging polluters, who caused *le monde* to become *immonde* ("filthy"), as Lacan phrases it (1960/1974/2005, p. 76).

We have now introduced Lacan's four discourses: the discourse of the Master (S_1 as agent), the university (S_2 as agent), the hysteric (*$* as agent) and the analyst (the object *a* as agent or actant):

$\frac{S_1}{\$} \rightarrow \frac{S_2}{a}$	$\frac{S_2}{S_1} \rightarrow \frac{a}{\$}$	$\frac{\$}{a} \rightarrow \frac{S_1}{S_2}$	$\frac{a}{S_2} \rightarrow \frac{\$}{S_1}$

In the final two sections of this chapter, I will elucidate the psychoanalytic approach to technoscience by analysing two more case histories: the malaria mosquito and the nude mouse.

Second Case History: Malaria Research

Imagine an international team of life scientists (S_2 as agent) studying malaria mosquitoes. Let us pay due attention to language first of all. The official name for the malaria mosquito, as a particular genus of mosquitoes, is ἀνωφελής, which literally means "useless" (ἀν + ὄφελος), so that the negating prefix "ἀν" already posits the object as a non-object, a refuse. Precisely this allegedly *useless* object, however, may become the focus of choice on which thousands of academics build their careers, so that ἀνωφελής actually provides them, not only with an income, but also with a lifeline into technoscience. Technoscientists may spend years of their lives studying these "useless" entities, hopefully to their benefit, and to the benefit of society as well. What is in a name? A contradiction, for why studying something which is literally useless? A contradiction is a symptom and symptoms make us realise that the focal point of attention is not the mosquito as such, but something "other", something noumenal, something hidden (the object *a*). The mosquito itself merely functions as a cover or carrier for *something else*, namely a parasite officially known as *Plasmodium falciparum*: a dangerous, potentially lethal pathogen, an intruding, disruptive element, the object *a* of malaria research, hiding in the mosquito's intestines, penetrating human skin tissue and transmitted by the bite of a female *anopheles*, causing malaria in humans. Notice that the intentionality of technoscientists is under the sway of negation, because the envisioned outcome of the research is to *eradicate* this parasite (and / or the mosquitoes carrying it, as vectors). The will to decipher (the parasite's secret code) is driven by a will to obliterate and to annihilate. The dialectics of global health requires that a positive result (the eradication of malaria) is the negation of negativity. Remember that life and heath are never a given, but always the outcome of a syllogism (the negation of a disrupting negation, represented by the malaria bug).

Current research focusses on proposals to negate (eradicate) *anopheles* with the help of a CRISPR-Cas9 gene drive system (Scudellari, 2019; Čartolovni, 2017), either by targeting and deleting a particular gene which is vital for female fertility, or by targeting and knocking out the *FREP1* gene, which encodes an immunity protein which helps malaria parasites to survive inside the mosquito's intestines. In other words, we notice a series of displacements (mosquito → intestines → parasite → protein → gene) as successive targets of the death drive of technoscience. A gene drive is basically driven by a death drive, a will to eliminate.

Suppose that the research team mentioned above indeed considers developing a CRISPR/Cas9 -mediated gene to knockout *FREP1* in Anopheles (Dong et al., 2018). This FREP1 gene is not an "object", at least not in the way a mosquito is (as an insect we can see, and whose bite produces a stinging sensation). A gene is not something directly visible or tangible, something we may directly relate to. It is something noumenal. It is a sequence of nucleotides, a piece of DNA, a program containing instructions for protein production. In short, the focus of attention is not the mosquito (the tiny biting female vampire), but a partial object or sur-object, the targeted gene, or a particular DNA sequence belonging to the CRISPR/Cas9 family that will allow researchers to knock out (eliminate) this gene with the help of a molecular scissor. Malaria (a threat to human health, a challenging *negation*) is to be eliminated with the help of a knock-out device (the negation of this negation) to safeguard the immunity of the human species.

Gene drive exemplifies the inherent *negativity* of technoscience. A gene drive is a *disruptive* technology, intentionally disrupting key genes essential for female fertility in mosquitoes, so as to *eradicate* disease vector populations. "Selfish" genetic elements are consciously exploited to spread a genetic modification from laboratory mosquitoes to field populations (Windbichler et al., 2011) and to confer a "negative fitness effect" on the target population (Hammond et al., 2017). Notice that "negative fitness" is a dialectical term, indicating that molecular life sciences research is *inherently dialectical*, it is the negation of a negation (targeting a parasite who is targeting us). Gene drives are self-perpetuating, however. They spread by themselves and, once implemented, continue to radiate through the target population (Scudellari, 2019; Collins et al., 2017). They are resistance proof (Kyrou et al. 2018) and there is either no evidence for the occurrence of resistant mutations, or the likelihood of occurrence can be intentionally reduced (Hammond et al., 2017). The big issue is not whether gene drives work, but how to control, contain and reverse them, how to disrupt the disruptor, the killer machine, if necessary? Again: how to negate the negation?

There is evidently a hint of perversity at work in studying vampire mosquitoes and lethal pathogens dwelling in their intestines. As Lacan indicates, there is a structural concordance between university discourse and perversity, namely the obsession with a partial object, dangerous and enigmatic, extraordinary and valuable (referred to by Lacan as object *a*). The product of the process will be a series of publications: papers in academic journals (probably containing glossy images of pathogens and DNA sequences). These products can be considered as "sublimation", a symbolic sublation and justification of the researcher's questionable desire. In addition, although biomolecular research as such will focus on targeted non-objects or sur-objects (e.g. a gene, a strain of nucleotides, etc.), other issues are involved as well, such as biosafety considerations. When working with potentially dangerous organisms, how to prevent dangerous pathogens from leaking into the outside world, or how to prevent pathogen theft? Also, environmental considerations are evidently at stake: what will be the ecological collateral damage of eradicating anopheles, this allegedly *useless* mosquito? And finally, how to prevent a unilateral flow of (patentable, valuable) knowledge from sub-Saharan Africa to

research institutes in the global North? For indeed, while ἀνωφελής means useless, or even "unprofitable" (ὄφελος may also mean *benefit* or *profit* in Greek), the knowledge procured and extracted from researching these mosquitoes may become a valuable commodity (may be sublated into patentable knowledge and similar ownable products, appropriated by the global technoscientific enterprise).

In short, in malaria research, a plethora of philosophical niceties are involved, from dialectical ontology up to the normative dimensions of global biodiversity, ownership (accessibility) of knowledge and intellectual property rights. These additional challenges may give rise to the development of additional (complementary) forms of expertise, such as environmental science or bioethics – e.g. genres of expertise concerning risk prevention and benefit sharing: how to share the financial benefits derived from researching "unprofitable" mosquitoes? These specific forms of auxiliary expertise display a tendency to revert to the syllogism of university discourse as well: the ethicist operating as a qualified expert (S_2), whose expertise should not impose a barrier to technoscience, nor limit its progress, but merely help to establish the best results for an equal and inclusive society (Neves & Druml, 2017). A form of expertise in short which, in the discourse of the analyst, becomes suspended.

The oblique perspective adopted by continental philosophy of technoscience concurs with what Lacan refers to as the discourse of the analyst:

a	*$*
S_2	S_1

In this type of discourse, the focus is on questioning (zooming in on) the symptomatic intricacies emerging in the interaction (above the bar) between the craving subject's will to know (*cupido sciendi*) and an enigmatic agent. This interaction is represented here by the tormented expert (*$*), driven into action by the elusive, dangerous object, now acting as agent or actant (*a*). The focus is on the disparities of the situation, e.g. on explaining how an insect (formally known as unprofitable) becomes a source of value, triggering a plethora of research initiatives. The epithet ἀνωφελής is symptomatic of the dialectical disparities involved. Moreover, also in this case there is an (unintended) product or by-product involved, as indicated by the scheme, namely something normative (S_1 in the lower-left position). Eventually, philosophical involvement may result in a normative "product", e.g. a series of normative (bioethical) guidelines for safeguarding research integrity and implementing policies of benefit sharing. A normative outcome or product is what philosophers are eventually expected to produce: a series of normative principles or guidelines (S_1), so that "normal" university discourse may be re-established (via a clock-wise quarter turn of the scheme) and safeguarded from disruption. This normative outcome (in the form of ethical guidelines) replaces the imperatives of the Master, pushed beneath the bar in university discourse. Whilst emancipated (Enlightened) technoscience is still in need of legitimising directives, these are no longer provided apodictically (*ex cathedra*), but in a format qualified technoscientific experts can (be

trained to) work with, e.g. guidelines established by qualified normative (bioethical) experts, operating in accordance with the logic of university discourse.

This means that philosophers of technoscience themselves will be facing a chronic disparity as soon as they become involved in this type of research (Zwart, 2018a). While the philosophers themselves may prefer to study the dialectics of power and desire at work in actual research practices from an oblique perspective (thereby opting for the "discourse of the analyst"), they are eventually expected to come up with normative tools that legitimise their involvement (which would require a clock-wise turn, towards "university discourse"). Such normative tools (as products of their analyses) would allow researchers, research managers and funding organisation to address potential disruptions. Technoscience is an "administered world" where normative challenges must be addressed through ethical engineering. Technoscience seems in need of ethical expertise, rather than excessive problematisation and interminable questioning. This is an inherent antagonism or contradiction at work in the discourse of the analyst, which may result in a regression, when philosophers shy away from "interminable analysis" and revert to the position of qualified bioethical experts (exchanging an oblique perspective for validated expertise, and the discourse of the analyst for university discourse, a change of roles which requires a clock-wise quarter-turn of the quadruped scheme to the right).

Lacan's theorem of the four discourses is sometimes regarded as a device which operates in a more or less mechanical manner and therefore subjected to the same kind of criticism also directed at Hegel, whose dialectical schema's (A, B, E, etc.) may likewise suggest a mechanical practice of applying triadic formulae, so that every antagonism inevitably radicalises into extremity and thereby becomes resolved, and so forth. What is obfuscated in such a mechanistic misunderstanding is that what we are dealing with are hazardous and disconcerting processes. As Žižek (2016/2019) phrases it, in dialectical processes, there is no "normal progress". Dialectical processes involve obstacles, inhibitions, impediments, inertia, fixations, repetition and the like. Why do we pass from one position to the next? Why do we move from the discourse of the analyst to university discourse and back? This does not happen "automatically". Things become disrupted because of the experience of getting stuck. Dialectical experience is first of all the experience that something is *not* working. As an example, Žižek mentions Hegel's comments on phrenology, i.e. the conviction that the mind is a bone, i.e. that the characteristics of the human psyche are conditioned by the shape of the skull. A similar idea is present in the claim that human existence is essentially conditioned by the genome. Such objectifications prove a dead-end. On closer inspection, *nothing* is explained by such a claim, so that, eventually, even stringent partisans are forced to mitigate their views and to allow other factors to "compromise" their truth. Eventually, research becomes impeded by the weight of such claims (p. 77), while otherness reappears precisely in that which the claim initially excluded ("nurture" instead of "nature", etc.). This also applies to Lacan's discourses. Like the dialectics of master and servant, the shift from a Master's discourse to university discourse, and subsequently from university discourse to the discourse of the analyst, is an intricate and hazardous process, not at all a mechanical routine.

Third Case History: The Nude Mouse

As indicated, the body of organisms operates as an immunisation device safeguarding the integrity of individuals. On closer inspection, immunity is a phenomenon which requires thorough dialectical rethinking (Gilbert & Tauber, 2016). Biology, these authors argue, is a "dialectical discipline", and living nature a "dialectical world" (p. 842). The initial view sees individuals as insulated organisms (M_1), threatened with negation by a hostile environment, teaming with pathogenic microbes from which they must be protected (M_2). This antagonistic, defensive view, Gilbert and Tauber convincingly argue, must be displaced by a more comprehensive, dialectical approach which sees organisms as "holobionts", as consortia of hundreds of symbiotic species, e.g. host organisms and their microbiomes. As a result, immunity is not a purely defensive mechanism (M_2), but the net balance between rejection and assimilation. Thus, the one-sided, defensive view gives way to a dynamical interaction between organism and ecosystem (M_3). This dialectic of immunity is given an additional dialectical turn in the case of laboratory animals, whose immune system is challenged for the purpose of research.

Wild type animals are recalcitrant objects, and therefore not the ideal (kenotic, transparent) targets of research, as this requires optimal plasticity and modifiability. Even in malaria mosquitoes, potential resistance to disruptive interventions remains an issue of concern. Inside the laboratory, we aim to penetrate nature and to explore the "things in themselves", with the help of research objects of choice, exemplified by a particular category of objects known as "model organisms". Their ontological status is fluid, hovering in the boundary zone between the artificial and the natural. They actually may be seen as representing an ontological category of their own, halfway between living beings and laboratory gadgets, trans-animals as it were.

Initially (M_1), we encounter the recalcitrance of life in the form of an epistemological obstacle: the resistance of living beings, whose bodies act as immunisation devices. This is the first moment, the first experience of "getting stuck": the undeniable nastiness of working with animal models, whose bodies are *really alive*, sensitive and irritable, so that research ambitions may be seriously impeded. To overcome resistance of the real, an element of sadism seems to be at work in animal research (M_2): the laboratory as a torture house, confirming the syllogistic congruence between university discourse and the position of the pervert.

Then, however, something unexpected happens. A laboratory artefact is produced by accident, a nude mouse, discovered in 1962. The nude mouse is by now a standard laboratory-dweller: a strain of mice with a genetic mutation resulting in the absence of a thymus and an inhibited immune system (due to a significantly reduced number of T cells). The nude mouse can therefore receive many different types of tissues, tumours and grafts, without mounting a rejection response. This is the technoscientific ideal of the natural: a system without opacity, without resistance. The nude mouse is a unique model for experimentally producing, imaging and treating tumours. The nude mouse embodies the second moment of the process, under the

sway of negativity (M_2), but now in a purified version. The nude mouse pushes the concept of a model organism to its extreme. Its ontology is characterised by *absence* (absence of a thymus, absence of an immune system, absence of hair).

The genetic basis for the nude mouse (as the phenotype) is a mutation: a disruption of the FOXN1 gene (the genotype), which occurred by accident, but was immediately exploited. The most striking outward appearance is the absence of fur. Because of a monogenetic defect (in the FOXN1 gene) the nude mouse suffers from a number of deficits which, in the context of a laboratory (as a world *in reverse*), actually constitute a benefit. Normally, research with animals is under the sway of the dialectic of action and reaction, so that intrusion unleashes resistance, a dialectic which gave rise to the discovery of "irritability" by Albrecht von Haller and others already in the eighteenth century. And indeed, disruption and irritability are important components of the syllogism of animal research. The epistemology of disruption either functions *per via de levare*, by removing or disconnecting organs, one after the other (Zwart, 2015), or *per via di porre*, by adding something (a carcinoma, a tumorous growth), but the irritable animal's body offers resistance against such intrusions.

Irritability basically means that animals can suffer. Technoscientific research demonstrates that the *integrity* of the body is more than merely or normative principle, more than a mere "idea". Rather, it is a *dialectical* idea (in the Hegelian sense): an idea which *realises itself*, in the form of resistance or rejection, as the actualisation of the principle of integrity. Integrity as a *general* principle (A) is challenged by *particular* intrusions (in the context of an experiment: B), giving rise to a *concrete* response (e.g. rejection of the allograph: E). In the case of a nude mouse, however, the body responds with *indifference* to intrusions, so that the natural syllogism becomes disrupted ($A \rightarrow B \mid \rightarrow E$). The athymic, hairless (nude) mouse becomes a kenotic object, a living test-tube, a receptacle, perfectly modifiable, open to the negativity of technoscience.

Because of its inhibited immune system, the nude mouse becomes the ideal recipient of allografts and xenografts: obnoxious implants coming from other individuals or species: *extimate* intrusions, symbolising intimate disruptive otherness (Zwart, 2017; Aydin, 2021). The nude body displays a dramatic inability to eliminate the intrusion, but from the point of view of negativity, this deficit is actually a benefit (as two negatives yield a positive). The intrusive, extimate allo- or xenograft becomes the objects *a* of technoscience: a cancerous growth, a disruptive stain, something which can be meticulously monitored and quantified, the target of pictures and curves which can be incorporated in journal papers, while the mice themselves, after having reached their "humane end-point" – i.e. the condition when physiological or behavioural signs indicate that an experimental animal has attained the agreed maximum of pain or distress – are euthanised via a procedure known as cervical dislocation.

The nude mouse became a successful species, both commercially and research-wise (Rader, 2004). Nude mice are arguably the most widely used mammalian models in biomedical research, especially in oncology and immunology. A hairless creature whose immune system is compromised is sublated into something valuable

and positive (the negation of the negation). The nude mouse becomes especially beneficial for humans (for us, *naked apes*) because nude mice represent perfect models for studying illness in humans. Something negative, e.g. a cancerous tumour, inserted into the body, in the form of an allograft, becomes a highly valuable excess, the object *a* of biomedical research: the embodiment of something which should not be there, and is nonetheless meticulously monitored with care. The thing in itself is opened up, the body becomes transparent and the biomolecular dynamics of cancer can be studied. The divide between subject and object, phenomenon and noumenon is lifted.

Antagonisms and contradictions persist, however, notably coming from the super-ego of technoscience. On the one hand, the imperative is: continue to produce more data, in support of the "war on Cancer"! On the other hand, conflicts of conscience may arise, because of the inevitable nastiness of the handiwork of technoscience, framed as "necessary evil" (Pijnappel, 2016). Somehow, a contribution will be made, teleologically speaking (some progress in the interminable fight against cancer), but the chance that *this particular* experimental trial will have a beneficial result, remains infinitesimally small. The research effort will result in things like *papers*, *citations* and *additional research grants*, but cancer will not be eradicated. Rather, the War on Cancer proves an interminable affair. As Ellen ter Gast (2007) convincingly argued, should progress be made at all, nude mice rather than technoscientific research managers should be awarded the Nobel Prize.

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