

# *Fabricated Truths and the Pathos of Proximity: What Would be a Nietzschean Philosophy of Contemporary Technoscience?*

**Hub Zwart**

## **Foundations of Science**

The official Journal of the Association  
for Foundations of Science, Language  
and Cognition

ISSN 1233-1821

Volume 24

Number 3

Found Sci (2019) 24:457-482

DOI 10.1007/s10699-019-09599-3



**Your article is published under the Creative Commons Attribution license which allows users to read, copy, distribute and make derivative works, as long as the author of the original work is cited. You may self-archive this article on your own website, an institutional repository or funder's repository and make it publicly available immediately.**



# Fabricated Truths and the Pathos of Proximity: What Would be a Nietzschean Philosophy of Contemporary Technoscience?

Hub Zwart<sup>1,2</sup>

Published online: 1 March 2019  
© The Author(s) 2019

## Abstract

In recent years, Nietzsche’s views on (natural) science attracted a considerable amount of scholarly attention. Overall, his attitude towards science tends to be one of suspicion, or ambivalence at least. My article addresses the “Nietzsche and science” theme from a slightly different perspective, raising a somewhat different type of question, more pragmatic if you like, namely: how to be a Nietzschean philosopher of science today? What would the methodological contours of a Nietzschean approach to present-day research areas (such as neuroscience, astrophysics, synthetic biology or climate studies) amount to? In other words, my paper reflects a shift of focus from author studies to extrapolation. The design of my article is as follows. I will start with the question (already widely discussed in the expert literature) to what extent Friedrich Nietzsche (a classical philologist by training) managed to familiarise himself with the natural sciences of his epoch. Subsequently, I will outline some basic methodological and conceptual ingredients of Nietzsche’s philosophy of science, focussing on core issues such as “genealogy”, “interpretation”, “enhancement” and “truth”. Next, I will elucidate Nietzsche’s genealogical methodology with the help of three case studies (three representative samples if you will) taken from Nietzsche’s writings and dealing with physiology, astronomy and neuro-psychology respectively. Finally, I will present the methodological contours of a Nietzschean understanding of contemporary technoscience.

**Keywords** Friedrich Nietzsche · Philosophy of science · Nietzsche and science · Continental philosophy · Nietzsche studies

---

✉ Hub Zwart  
zwart@esphil.eur.nl

<sup>1</sup> Erasmus School of Philosophy (ESPhil), Erasmus University Rotterdam (EUR), Burgemeester Oudlaan 50, 3062 PA Rotterdam, The Netherlands

<sup>2</sup> Rotterdam, The Netherlands

## 1 Introduction

Nietzsche's views on science (more precisely: on *natural* science) attracted a considerable amount of scholarly attention during the past two decades, after having been ignored for quite some time (Babich 1999, p. 1; Heit 2011, p. 7). Multiple volumes (e.g. Babich 1999a, b; Moore and Brobjer 2004; Heit et al. 2011; Heit and Heller 2014a, b), monographs (e.g. Babich 1994; Moore 2002; Johnson 2010) and journal articles have now been devoted to this topic. This prolific scholarly discourse not only analyses Nietzsche's critical assessments of nineteenth-century scientific theories (e.g. his criticism of Darwinism), but also explains how Nietzsche incorporated scientific insights—such as Hermann von Helmholtz's sensory physiology (Reuter 2014) or Wilhelm Roux' experimental embryology (Müller-Lauter 1971/1999; Soderstrom 2009)—into his philosophy.

Nietzsche's attitude towards science is often regarded as ambivalent or even hostile. As Gregory Moore phrases it, in his introduction to a volume entitled *Nietzsche and Science*, although Nietzsche is no longer regarded as the “arch-critic” of science (2004, p. 1), his stance towards science (in his earlier, but also in his later writings) is decidedly one of suspicion.<sup>1</sup> According to Nietzsche, scientific insights are basically falsifications (Meyer 2011; Andresen 2013; Remhof 2015a, b; Remhof 2016). For Nietzsche, nature itself is chaos, devoid of any intrinsic properties or structure, a proliferation of random chance events, so that any discernible order is produced by us. Nature only exists for us as a coherent whole insofar as it affects us through our bodies, Nietzsche argues, for it is through our bodies that we understand and organise our world and populate its chaos (Soderstrom 2009, p. 64). Through bodily interactions with reality, the intellect receives a raw text, which is assimilated, adjusted and transformed into a controllable and meaningful environment through interpretation, rectification and falsification. For Nietzsche, interpretation means domestication and accommodation, and science as a practice was developed to *make* nature predictable, and thereby liveable and manageable to some extent.

Building on the scholarly literature, in interaction with my own readings of Nietzsche during the past decades, this article addresses the “Nietzsche and science” theme from a somewhat different perspective, raising a different kind question than the ones addressed by the majority of Nietzsche scholars, more pragmatic if you like, namely: how to be a Nietzschean philosopher of science *today*? What would be the methodological contours of a Nietzschean approach to present-day research areas such as neuroscience, astrophysics, synthetic biology or climate studies? In other words, this paper entails a shift of focus from *author studies* to *extrapolation*. These two orientations are not antithetical, of course, for the latter evidently remains highly dependent on the former. Nonetheless, extrapolation involves a different style of reading and assessing Nietzsche's oeuvre than the more usual hermeneutical one.

My emphasis on contemporary science (rather than on nineteenth-century science, the science of Nietzsche's own era) stems from my “position” (both figuratively and literally).

<sup>1</sup> “Die kritische Haltung zur Rolle der Wissenschaft ist Nietzsches erster eigenständiger philosophischer Gedanke, sie begleitet ihn durch alle Phasen seines philosophischen Denkens. Der Autor wechselt die Form und die Strategie der Darstellung, die kritische Botschaft bleibt die gleiche” (Borsche 2011, p. 466). Compare this to two other quotes from the same volume: “Nietzsche's thinking is far from being hostile to or dismissive of science, his many critical comments with respect to it notwithstanding” (Schacht 2011, p. 161); “Nietzsche has an uneasy and conflicted relation to science. He attacks it forcefully and on many grounds—but as we know he also expresses quite positive views of it” (Richardson 2011, p. 315). See also: “Nietzsche has shown us how the philosophy of science should be done” (MacIntyre 1999, p. xv).

For almost two decades, my daily audience (as an “in-house philosopher”, employed at a Faculty of Science) consisted of scientists and science students, in other words academics who were directly involved in conducting scientific research. How to assess and discuss their work and experiences from a Nietzschean perspective? Can Nietzsche’s concepts and methods be of help in coming to terms with the scientific revolution that is currently raging (at an astonishingly disruptive pace) in the high-tech laboratories of our global research ecosystem?

The design of this article is as follows. I will start with the question (already widely discussed in the literature) to what extent Friedrich Nietzsche (a classical philologist by training) managed to familiarise himself with the natural sciences of his epoch (aptly referred to as the “age of science”: Knight 1986; Moore 2004, p. 2; Heller 2014, p. 7; Heit 2014, p. 23). Subsequently, I will outline some basic methodological and conceptual ingredients of Nietzsche’s philosophy of science, focussing on core issues such as “genealogy”, “interpretation” and “truth”. Next, I will elucidate Nietzsche’s genealogical methodology with the help of three case studies (three representative samples if you will) taken from Nietzsche’s writings and dealing with physiology, astronomy and neuro-psychology respectively. Finally, I will present the methodological contours of a Nietzschean understanding of contemporary technoscience.

## 2 Peering Through the Key-Hole: Nietzsche’s Access to Science

Before addressing what Nietzsche *thought* about science, we should first of all consider what he actually *knew* about science. In the scholarly literature on this issue, reference is often made to a famous line in *Ecce Homo* where Nietzsche looks back on what he, in retrospect, considers his most regrettable “blunder”, namely his fateful decision to become a classical philologist. *Human, All too Human*, he tells his readers, is the memorial of a crisis, written during a period in his life when he thoroughly came to regret all the precious time he had “squandered” on philology.<sup>2</sup> A burning thirst overcame him and from that time onward he decided to do nothing else (“...von da an habe ich in der Tat nichts mehr getrieben...”) than studying physiology, medicine and natural science (*Ecce Homo, Human All too Human* Sect. 3). And indeed, the famous first aphorism of the first part of *Human, All too human* reflects this intention, for it conveys the claim that “all we need is a chemistry of the moral, religious, aesthetic conceptions and feelings” (*Ecce Homo, Human All too Human* I, Sect. 1).

Several experts have pointed out, however, that this remark in *Ecce Homo* should not be taken too literally. Although the word “getrieben” may suggest otherwise, Nietzsche never actually *practiced* science (in any practical sense of the term) and it even seems highly unlikely that he ever physically visited a laboratory or conversed with practicing scientists in person. His knowledge concerning the natural sciences came to him via his readings. Karl Schlechta (1969), for instance, after raising the question whether Nietzsche ever

<sup>2</sup> Philology is the study of language: its grammar, history and development, by critically assessing historical sources. It is a branch of research which emerged in Hellenistic libraries (e.g. at Pergamum and Alexandria), but resurged as “classical philology”: a core academic discipline in nineteenth-century Europe focussing on ancient Greek and Latin.

seriously studied (natural) science,<sup>3</sup> already pointed out that his posthumous library contained a considerable number of scientific publications (III 1445). And in his voluminous Nietzsche biography, Curt Paul Janz (1978) mentions something which is often referred to in the more recent “Nietzsche and science” literature, namely his plans to study chemistry in Paris, which came to naught because, precisely at this moment in his life, a professorship in philology at the university of Basel was unexpectedly offered to him. This missed opportunity (to expose himself to nineteenth-century science) could never be made up for later, or only in an autodidactic manner, and may even be considered as *the* “tragedy of his life” (Janz 1978, I p. 319; cf. Heit 2014, p. 32).

Still, most scholars agree that Nietzsche, notwithstanding his lack of scientific training, and especially his inaptitude for (and dislike of) mathematics (Brobjer 2004, p. 21, p. 24; Heit 2014, p. 33; Schiemann 2014, p. 47), invested much time and effort in familiarising himself with important scientific debates (Moore 2004, p. 12; Heit and Heller 2014a, b, p. 2; Dahlkvist 2014, p. 138), such as evolutionary biology (Moore 2002) and organismal biology (Müller-Lauter 1971/1999). And although Nietzsche’s reading focussed on specific scientific issues (on specific discursive “samples” as it were), many Nietzsche experts endorse Alwin Mittasch’s claim that, despite his limited scientific training and selective reading, Nietzsche demonstrated a rare talent for discerning the basic tendencies at work in the sciences of his time (Mittasch 1952, p. 50; cf. Schiemann 2014, p. 47).

At the same time, it is important to point out that a number of obstacles or filters were at work. Nietzsche’s access to science was primarily provided by popular books addressing non-expert audiences (Schiemann 2014, p. 47; Solies 2014, p. 108). He read Wilhelm Roux’s monograph *Der Kampf der Teile im Organismus* for instance, but did not consult primary scientific journal articles (by Roux or others) on embryology or organismal physiology, i.e. the technical literature, addressing expert peers. Moreover, in terms of material circumstances (or *Unterbau*, to use the Marxist phrase), Nietzsche spent most of his intellectual life far removed from the cities and universities where the laboratories and research institutes of his era were located. After resigning from his professorship in 1879 (because of health problems), Nietzsche basically became a (bourgeois) tourist, living on an allowance and dwelling in Mediterranean tourist sites, such as Turin and Nice, or in mountain resorts, experiencing Alpine nature during sojourns as a solitary walker. Indeed, exposure to Mediterranean and Alpine climates was a key ingredient of his existential diet, his therapy. This exile, however, inevitably implied a significant *distance from science*, and the larger part of his philosophical existence was spent far removed from cities (such as Paris or Berlin) where scientific research was actually conducted and most laboratories could be found. Therefore, it is important to keep in mind that, whenever Nietzsche speaks about science, he does so solely on the basis of his *reading* practice. A discursive filter is at work. Nietzsche focusses on *published* science (the context of justification) and is much less familiar, or even completely unfamiliar, with science as a *practice* (the context of discovery, the research practices and research sites where scientific facts were actually produced).

Therefore, although Nietzsche worked hard to acquaint himself with scientific ideas and concepts (such as, for instance, theories of evolution), he was less acquainted with the menial, hands-on, experimental *methods* employed in science. Indeed, in Nietzsche’s writings about *Wissenschaft*, a hint of (“aristocratic”) disdain for the handiwork of science can even be discerned. Researchers are depicted as toiling workers, as servants, rather than as masters, and

<sup>3</sup> “Nietzsche und die Naturwissenschaft? Hat er sich denn je ernstlich mit ihr beschäftigt?” (Schlechte 1969, III, 1443).

for Nietzsche, experimental research is decidedly a working-class profession, conducted with the help of technical equipment. See for instance his denigrating comments about researchers as “modest workers”, performing their handicraft in “some little corner”, driven by *despectio sui* (self-contempt), rather than by grand ideals (*Genealogy of Morals* III, Sect. 23).<sup>4</sup> Notwithstanding Nietzsche’s practice of self-experimentation (using himself as a research subject to systematically explore the impact of climate, fresh air, diet and exercise on his mental and physical condition), the proletarian, plebeian, manual, urban, big city-life dimensions of practical science were something which Nietzsche (as a free-thinking aristocrat) evidently abhorred. His working-class phobia, if you like, seems symptomatic of his aristocratic (or rather: high-bourgeois) sense of taste, also when it comes to evaluating intellectual pursuits.

This is also discernible in his comment (in *Beyond Good and Evil*, Sect. 211) that we should stop confusing scholarly and scientific labourers with “philosophers” (“Ich bestehe darauf, dass man endlich aufhöre, die philosophischen Arbeiter und überhaupt die wissenschaftlichen Menschen mit den Philosophen zu verwechseln”). This contempt for the daily handiwork of science is part of Nietzsche’s pathos of distance, no doubt, but it may easily become an obstacle for understanding what science (in the sense of: laboratory work) is about and how scientific facts and knowledge claims are actually produced.

### 3 Conceptual Ingredients: Nietzsche’s Philological Physiology

Nietzsche, as we have seen, was a classical philologist who, after a profound existential crisis (and in order to improve his health: *Human, All-Too-Human*, *Prelude* Sect. 5), decided to turn his attention towards chemistry, physiology and other scientific fields, albeit as an autodidact, without any formal training or practical experience. He nonetheless remained a philologist all the way, for instance because, as indicated, he approached and assessed scientific research basically as a *reader*. His “chemistry of concepts and sensations” continued to rely to a considerable extent on philological tools and methods as well as on philological suspicion. Nietzsche’s professional sensitivity and *akribeia* focussed on the descent and history of words and on discursive, rhetorical aspects such as dialect and style (Babich 2011, p. 297, p. 298). Indeed, his methodological suspicion was a philological stance, for classical philologists were specialised in questioning the authenticity of texts and the identity of their authors, paying due attention to things like socio-cultural background, class, vocabulary and so on. Notably James Porter (2000) has convincingly argued that also in his later works, Nietzsche’s philosophical critique (his cultural criticism) should be seen as an extension of his philology: reading, deciphering and interpreting texts in order to detect self-betraying signs of falsification or self-deceit (p. 4). His practice of reading, his style of his thinking remained thoroughly philological, Porter argues (p. 11), and the idea that Nietzsche ever abandoned philology must be dispelled as a “myth” (p. 15). A key ingredient of the philological repertoire is

<sup>4</sup> “Es gibt ja genug braves und bescheidnes Arbeiter-Volk auch unter den Gelehrten von heute, dem sein kleiner Winkel gefällt, und das darum, wie es da gerade so viel Nützlichs zu tun [gäbe]. Ich widerspreche nicht; am wenigsten möchte ich diesen ehrlichen Arbeitern ihre Lust am Handwerk verderben: denn ich freue mich ihrer Arbeit. Aber damit, dass jetzt in der Wissenschaft streng gearbeitet wird und dass es zufriedne Arbeiter gibt, ist schlechterdings *nicht* bewiesen, dass sie Wissenschaft als Ganzes heute ein Ziel, einen Willen, ein Ideal, eine Leidenschaft des großen Glaubens habe. Das Gegenteil, wie gesagt, ist der Fall” (*Zur Genealogie der Moral* III, Sect. 23). As I read it, although Nietzsche “delights in their work”, he condescendingly looks down upon these humble, honest, toiling workers.

distrustfulness and scepticism towards transmitted concepts and transmitted texts, culminating in a “hermeneutics of suspicion” (p. 39). Indeed, even his key concept “genealogy” was of philological descent, coined by Nietzsche’s mentor Friedrich Ritschl (Benne and Santini 2014, p. 139).<sup>5</sup> Thus, rather than replacing philology by physiology, from *Human, All-Too-Human* onwards Nietzsche endeavoured to “practice” physiology from a philological perspective.

It is clear, moreover, that his envisioned exodus from classical philology (as a humanities field in the sense of *Geisteswissenschaft*) towards natural science (*Naturwissenschaft*), from philology to physiology (Zwart 2000) entailed a number of challenges, first and foremost because of the different styles of thinking represented by these research practices. Philology exemplified the nineteenth-century *Bildung* concept. At gymnasiums across Europe, but especially in Germany, ancient Greece was regarded as the paragon of human culture. *Bildung* (edification, humanisation) of the future bourgeois elite was realised via systematic exposure to the ancient legacy, first and foremost via reading (Sloterdijk 2001, p. 305). And philologists not only acted as qualified custodians of the classical moral and aesthetical ideals conveyed by this legacy. Via their grammatical and interpretative exercises, they also propagated a scholarly ideal: namely the ideal of textual carefulness and critical exactitude. Philology entailed a methodical and meticulous strategy of reading, bent on detail and precision, often resulting in exposure of instances of inauthenticity. Also in later writings, Nietzsche demonstrated his fidelity and respect for careful, methodological reading, imprinted in him by his philological teachers (*The Anti-Christ*, Sect. 59).

From the 1860s onwards, however, the *Bildung* concept was challenged by a new idea, namely that new generations should be edified via exposure to science and technology, rather than book reading, preferably by practicing experimental scientific research (Zwart 2000, 2008a, b). The scientific method was expected to foster a radically non-authoritarian attitude of self-criticism and carefulness. Science requires a fundamental willingness to confront established convictions (“prejudices”) with facts, produced in a methodical and verifiable manner. In terms of zeitgeist, the emergence of the scientific ideal reflected a shift from idealism, neo-classicism and Romanticism towards realism and positivism. Whereas philology (reading classical texts as a moral, edifying exercise) focused on the soul, scientific research focussed on the body, on the manual and experiential aspects of knowledge production, seeing the body not as an idealised gestalt (a work of art, exemplified by ancient sculptures), but as an organism, as something that is physically and organically real. Thus, physiology rather than philology now became the model discipline, a shift which is reflected in Turgenev’s novel *Fathers and Sons*, published in 1862 and devoted to a generation conflict (Zwart 2000; Van Tongeren 2011). The “fathers” (Nikolai and Pavel Kirsanov) are romantic landlords who value art, culture, novels and good manners. They exemplify an aesthetic and educated (but also fairly idle and melancholy) life-style. In their youth, they had visited the university, not in order to become physicians, but to become civilised, well-educated gentlemen. The new generation of “realists” and “nihilists”, however, is represented by Bazarov, a brash and ambitious youngster interested solely in natural science, in physiology and chemistry. Bazarov spends most of his time dissecting frogs. He despises everything that has to do with sentimentalism, romanticism and aestheticism.

<sup>5</sup> For Nietzsche, “genealogy” means: questioning the descent and historical vicissitudes of terms, focussing on remarkable shifts of meaning, by pointing out, for instance, that “person” initially functioned as a theatrical term (“mask”), “subject” as a political term (subjects of a sovereign), “guilt” as an economic term (“to be in debt”), etc.



He visits the Kirsanov estate during the summer holidays not to expose himself to the mysterious charms of provincial sunsets, but in order to experiment on frogs—his favourite model organism. Bazarov is referred to as a “nihilist”: someone who “looks at everything critically”, who does not take anything for granted, not even moral ideals. All humans are similar, from a scientific point of view, he claims, and slight individual variations (i.e. “character”) are of no great importance. Bazarov has no faith in moral principles, only in frogs (that is: in systematic experimental research). While Nikolai and Pavel Kirsanov read the lofty works of Goethe and Schiller, Bazarov prefers to read German chemists and physiologists, claiming that even a mediocre chemist is twenty times more valuable than the greatest poet. Bazarov emphatically relies on scientific methods, discarding the aesthetical life style of the older generation as a waste of time.

This socio-cultural transition from philology to physiology as a paradigm field entailed a revaluation of values, to which Nietzsche was sensitive. Unlike Bazarov, however, Nietzsche never went so far as to work with frogs himself. While being seriously interested in science, he continued to adopt a philological approach to science as we have seen. He analysed scientific textual materials *more philologico*, dissecting them with the help of his philological hammer, stethoscope and magnifying glass. One of the results is that he continues to see science basically as a practice of *interpretation*. For Nietzsche, all human interpretations of nature are *appropriations* of nature (Drenthen 2002) and this also applies to modern science. Science, Nietzsche argues, aims to acquire mastery over nature by interpreting the world in a certain manner, namely in accordance with laws, hypotheses and expectations. Even physics, as he sees it, amounts to nothing but interpretation, an arrangement of the world in accordance with our interests, a technique of domination aimed to overcome resistance.<sup>6</sup> In *Beyond Good and Evil*, Sect. 22, for instance, Nietzsche presents himself as “an old philologist” who cannot desist from putting his finger on the naive mode of interpretation entailed in the phrase “Nature’s conformity to law”. This exemplifies an instance of “bad philology”, he argues,<sup>7</sup> for in the raw text of nature, laws are lacking: all laws are interpretations, and the very idea of a law is a human concept projected onto nature: an instance of anthropomorphism or humanisation. And of course, even Nietzsche’s own framing of nature as a text (something that is to be interpreted) is a (consciously used) metaphor itself.

For Nietzsche, interpretation basically means rectification (*Zurechtmachung*). Indeed, Nietzsche interprets “interpretation” philologically, and from a position of philological suspicion, namely as mistreating, adjusting, shortening, omitting, filling-out, inventing or falsifying more original versions of the text (*Vergewaltigen*, *Zurechtschieben*, *Weglassen*, *Aneignen*, etc.), practices which inevitably result in falsifications (*Fälschungen*). The objective of Nietzsche’s philosophical suspicion is to unmask (*entlarven*) these falsifications. This results in a *philological* approach to science: scientific facts or observations do not speak for themselves, but are actively adapted, assimilated and adjusted by scientists. To take an example from contemporary science: Nietzsche would refuse to consider a human genome sequence as a primordial text, as the *Grundtext homo natura* (*Beyond Good and Evil* Sect. 230), but rather as a cleansed, adjusted, rectified and falsified version of such a text.

<sup>6</sup> “[Auch Physik ist] nur eine Welt-Auslegung und -Zurechtlegung ... und nicht eine Welt-Erklärung” (JGB Sect. 14; cf. MacIntyre 1999; Anderson 2011).

<sup>7</sup> “Der wissenschaftliche Optimismus und Positivismus verstößt ... gegen die elementare Regel seriöser Philologie, Interpretation und Text nicht zu verwechseln” (Heit 2011, p. 14).

This is quite clearly expressed in Nietzsche's famous aphorism about fictitious facts (*facta ficta*: *Dawn of Day*, Sect. 307). Genealogically speaking, there is no difference between "facts" (originating from the Latin verb *facere*, to produce) and "fictions" (from the Latin verb *ingere*, to bring forth: literally, with your fingers). Both activities result in *fabrications*. Indeed, from a Nietzschean point of view, scientific *facts* are basically *fabricated* (albeit in a literal, not necessarily pejorative or fraudulent sense) and to ignore this would be a symptom of self-deceit. Like a suspicious document (scrutinised by professional philologists) a scientific document is pervaded by interpretations which deserve to be questioned. The published document is, in all probability, a significantly *adapted* version of the original document (say: the raw laboratory notes). As a rule, a scientific paper is not an authentic, primary account, but a thoroughly processed piece of literature, handled by multiple hands, by multiple authors, supervisors and editors. To rephrase it in contemporary terms: a scientific paper results from the conscious efforts of multiple authors to adjust their original observations to the style and format of an academic paper, reflecting and adhering to the logic of the scientific method. This implies, however, that there is an obvious tension between the experimental work as actually conducted (with all its detours, mistakes, faux pas, etc.) and the polished version that is actually published (after being re-edited numerous times). Nietzsche's philological gaze is quite sensitive to such tensions. A Nietzschean gaze will be eager to spot the traces of these processes of textual massage or "falsification" (*Zurechtmachung*) as he phrases it. From a Nietzschean perspective, and in contrast with how these terms function in contemporary academic discourse (Zwart 2017a), "fabrication" and "falsification" are not seen as instances of "scientific misconduct" (i.e. as deviance, as something which ought to be avoided), but as inevitable and inherent features of scientific *interpretation* (i.e. appropriation) of reality as such. For Nietzsche, the translation of raw sense data into scientific discourse always and necessarily implies processes of falsification.

These processes, moreover, symptomatically reflect how the scientific will to know is far from disinterested but should rather be seen as infected and permeated by a pervasive will to power.<sup>8</sup> From a Nietzschean point of view, scientific interpretations and fabrications are efforts to acquire mastery over nature and to "humanise" nature, namely by adapting the chaos of nature to our anthropomorphic expectations, needs and concerns, thereby making chaotic nature predictable. The progress of science through *verification* (making-true) is a very active process which proceeds via *rectification* (adjustment). Laws of nature are *enforced* upon nature, basically because this enhances our sense of power over nature. Nature is not like a book at all, but is actively *transformed* by science into something textual, something which is readable and editable (Zwart 2016a). To use a present-day example, this systematic "textualization" of nature is exemplified by genomics sequencing (since the 1990s) and, subsequently, by contemporary gene editing techniques such as CRISPR-Cas9. The important thing, from a Nietzschean perspective is that, in order to be able to *re-edit* living nature at all, nature should first of all be transformed into a *textual* phenomenon, namely with the help of high-throughput *sequencing* techniques, but this of course already entails an interpretation, a substantial adaptation, or even a *Vergewaltigung* of nature: a practice of technically *fingering* with nature.

<sup>8</sup> For Nietzsche, existence (both human and natural) entails struggle, not merely for survival, but for enhancement (*Steigerung*), so that the will to power is the relentless drive towards empowerment, appropriation, proliferation and optimisation, permeating human culture, but also nature as such, not only on the organismal, but even on the cellular level.

I will now further elucidate Nietzsche's philological take on science with the help of some concrete examples, namely three case studies which will allow me to point out both the strengths and the weaknesses of Nietzsche's approach. I will begin with an example from physiology (exemplifying Nietzsche's *philological* reading of *physiological* research).

#### 4 Case Study 1: The Animal-Machine

In *Anti-Christ* (Sect. 14), the following claim is made: "As regards animals, it was Descartes who first had the really admirable daring to describe them as *machina*; the whole of our physiology endeavours to prove this claim".<sup>9</sup> Let us consider this claim with due precision, dissecting it as it were. The strength of Nietzsche's analysis, I would argue, is his sensitivity to the extent to which physiology, rather than being "disinterested" ("objective"), is bent on verifying a basic idea or image, in this case the idea that animals are machines (in the early-modern, mechanistic sense of the term "machine"). Experimental research is under the sway of ontological convictions, and it is the task of a Nietzschean philosopher of science not only to bring these convictions to the fore, but also to question them (or rather: to reveal their questionability).

On closer inspection, however, if we subject Nietzsche's own text to a more suspicious reading, his assessment entails a number of shortcomings. Let me begin by pointing out that Nietzsche's statement is a composite claim, consisting of two parts:

- a. Descartes was the first author who had the admirable daring to describe animals as machines, and
- b. physiology as a research field is bent on demonstrating the truth of this doctrine.

Both claims are questionable, I would argue. First of all, from a genealogical perspective, the idea that animals are machines was not fabricated (let alone in a "daring" manner) by Descartes, for it can already be encountered in thirteenth-century scholasticism. Nietzsche may even have been aware of this, as suggested by his use of the Latin noun *machina*. In his *Summa Theologica* (Pars 1a 2ae, Q XIII), for instance, Thomas Aquinas (1922) already argues that, although animals may seem endowed with the faculty of free choice, in reality their movements and behaviours are completely pre-determined. Animals basically function like *horologia*—i.e. clockworks (Zwart 1997), a thirteenth-century invention.

The second part of Nietzsche's claim is also problematic. From the very outset, modern physiology was far less mechanistic than Nietzsche seems to presume, up to the point of being anti-mechanistic (anti-Cartesian) even. While Descartes based his claims primarily on anatomical research with animal corpses,<sup>10</sup> physiologists (by conducting their

<sup>9</sup> "Was die Tiere betrifft, so hat zuerst Descartes, mit verehrungswürdiger Kühnheit, den Gedanken gewagt, das Tier als *machina* zu verstehen: unsre ganze Physiologie bemüht sich um den Beweis dieses Satzes" (Nietzsche, *Der Antichrist* 1980, Sect. 14).

<sup>10</sup> Descartes occasionally practiced vivisection. In 1638 for instance, he reported having practiced vivisection on a rabbit and in his *Description of the Human Body and of all its Functions* (an unfinished treatise written in 1647) he describes the vivisection of a dog, although he does not say whether he himself performed the operation. His anatomical (post-mortem) practices were much more thorough and systematic, however. Notably in Amsterdam (a centre of anatomy), where he lived in the Kalverstraat (the Calf Street, inhabited by butchers), dissecting animal carcasses, especially heads, became an almost daily practice for many years (Gaukroger et al 2000; Grayling 2006; McCance 2013).

experimental work with living animals, by interacting manually with living nature) inevitably discovered that animals are sensitive organisms, and therefore quite unlike machines. Albrecht von Haller (1707–1777), for instance, was a prominent physiologist who performed lengthy and careful experiments on live animals in the early 1750s. By doing so, he discovered that Descartes was wrong (Steinke 2005; Zwart 2008a, b, p. 106; Zwart 2016b, p. 618). The properties of muscle tissue cannot be explained in a purely mechanistic manner, Von Haller argued, notably because of their intrinsic tendency to react when excited: a phenomenon referred to by him as “irritability”, one of the primal discoveries of eighteenth-century physiology. In other words, from the very outset, physiologists were forced to acknowledge that animals are *not* machines, an insight which emphasises the methodological benefits of physiology compared to anatomical research and speculation, for although anatomy revealed the body’s inner structure, it often failed to understand the actual functioning of organs (such as muscles, hearts and livers).

This was not the end of the animals-are-machines idea, of course. During the second half of the nineteenth century, Claude Bernard for instance, the infamous father of vivisection, reverted to the Cartesian viewpoint that, in order to explore their inner machinery, the bodies of research animals had to be systematically “dismantled”, but this attitude was severely criticised, by Ivan Pavlov for instance, who argued that only normal, healthy animals can serve as reliable models in physiological experiments (Zwart 2016b, 2018). In short, instead of providing a paradigmatic *Leitbild* for physiological research, many prominent physiologists regarded the animal-machine model as questionable and misguided.

How to assess Nietzsche’s interpretation? On the positive side, I would argue that modern physiology *did* struggle with the animal-machine concept, as an ontological legacy of scholasticism, being alternately endorsed and refuted. And indeed, philosophers should pay close attention, like Nietzsche did, to the basic images and ontological convictions at work in scientific discourse. The animal-machine image provides an excellent example of this. Moreover, from a Nietzschean point of view it could be argued that, rather than providing us with objective facts, by coining the signifier “irritability”, Von Haller fabricated a scientific metaphor of his own (an anthropomorphic image even, given its association with *irritation* or *being irritated* as a typically human mental experience), adding it to the “army of metaphors, metonyms, and anthropomorphisms”, as Nietzsche phrases it in *On Truth and Lies in a Nonmoral Sense* (cf. Hossain 2013).

At the same time, I would argue that, rather than adapting observations to pre-existing images, Von Haller’s “fabrication” (the irritability concept) reflects his fundamental unease with Cartesian metaphysics and his sensitivity as a scientist to “raw nature” (animal suffering) compared to a bluntly mechanistic, Cartesian approach. What seems overlooked or underacknowledged in Nietzsche’s claim is precisely the menial, hands-on, experiential aspect of experimental work, the circumstance that Von Haller produced his neologism “irritability” in order to come to terms with vivid experiences obtained during his unsettling interactions with real, living and suffering bodies. The interpretation that “irritability” is merely another interpretation reflects Nietzsche’s philological bias, I would argue, and his suboptimal appreciation of research as a strenuous, manual, toiling, experimental *practice*, resulting in (sometimes quite painful) experiences which may challenge or refute basic ontological convictions. Yes, rectification undoubtedly occurs in physiology, but in multiple directions. Besides trying to *verify* basic convictions, these convictions may also be *rectified* or rejected (“negated”, dialectically speaking) by experimental experiences, by nature’s recalcitrant resistance to our conceptual will to power.

My question here is not whether or not Nietzsche’s two statements (the one about Descartes, the other about physiology) are valid or not, but *why* they are. Although they

tell us something about how, from a Nietzschean perspective, interpretation works and metaphors work (in this case: the metaphor of the animal-machine), Nietzsche's concise assessment runs awry to the extent that it insufficiently acknowledges the menial, practical, experimental dimension of physiology as a reach field. The Nietzschean viewpoint emphasises that, in the course of an experiment, scientific findings are fabricated, literally: they are produced with the help of scientific equipment and methodological techniques, but Nietzsche's emphasis on *Zurechtmachung* (omitting inconvenient results) and on *humanisation* (anthropomorphising life) underestimates the extent to which research actually amounts to a dialogical or dialectical process, often resulting in anomalies, in unexpected and frustrating findings. In contrast with textual analysis, physiological interpretation relies on manual and practical activities, such as (in the case of animal experimentation) the introduction of surgical methods, creating openings (windows) into the animal's body. And this experimental practice is enabled by something which seems neglected or at least underacknowledged in Nietzsche's reflections, namely the *technicality* of science, which not only allows for fine-grained manipulations, but also for quantification of experimental results via precision measurements (thus by-passing, enhancing and rectifying the impressions gained with the help of our natural sense organs). Rather than adapting real empirical nature to our basic convictions and our natural faculties of understanding, science is increasingly in the habit of outsourcing modification and observation to technical instruments (high-precision machines). Indeed, science (as a research *practice*) is characterised by a radical distrust in the reliability of human sense organs (the naked eye, etc.). By clinging to a purely *textual* understanding of scientific research, Nietzsche runs the risk of obfuscating the *technical* side of science, thus becoming imprisoned in his philological approach. In other words, his tendency to view science as a practice of verification may be an artefact of the philological filter he employs. I will come back to this later but will now turn to my second example.

## 5 Case Study 2: Self-Diminution

We already indicated Nietzsche's tendency to associate science, notably its toiling, manual aspects, with labour and the lower classes. Remember that laboratory literally means workshop. Genealogically speaking, moreover, *laborare* (manual labour) comes very close to *orare* (spiritual exercises), as already indicated by Saint Benedict's adage *ora et labora*. Indeed, in *Genealogy of Morals* III, Sect. 23, Sect. 25) Nietzsche claims that modern scientists are basically toiling ascetics. Rather than being antithetical to religious asceticism, Nietzsche's genealogical analysis aims to reveal that modern scientific research represents its most recent and refined expression, or at least offers it a hiding place (cf. Babich 1994, p. 8; Johnson 2010, p. 195; Ward 2011). Research is *exercise*, it entails discipline, self-sacrifice, dedication, devotion and hard work, in the vain hope of compensation or gratification somewhere in a distant future, by making ground-breaking discoveries, but prospects of acknowledgement remain highly uncertain or even blatantly unfair (Zwart 2010). For Nietzsche, modern scientists play a role similar to that of monks and hermits in medieval times: they sacrifice pleasure and health to knowledge production, imprisoning themselves in their laboratories as decidedly *unhealthy* ecosystems, lacking fresh air, the very opposite

of Nietzsche's own beloved Mediterranean or Alpine ambiances. Physiologically speaking, science is a form of asceticism.<sup>11</sup>

This is emphasised by a phrase already briefly referred to above, namely *depectio sui* or self-contempt: a lower-class attitude, according to Nietzsche, which contaminates the outcomes of scientific labour. For Nietzsche, self-diminution ("*Selbst-Verkleinerung*") is a key symptom of the ascetic condition, closely connected with self-contempt. And indeed, Nietzsche argues, an important indicator for the ascetic mood at work in science is that scientific research significantly contributes to advancing human self-betittlement. For Nietzsche, Copernicus is an exemplification of this trend (*Genealogy of Morals* Sect. 25). The renouncement of the geocentric worldview implies that we humans are suddenly reduced to a nullity, to cosmic insignificance. And this is not at all at odds with the ascetic ideal of course. Copernicus belonged to the Catholic clergy. He was a religious person, observing celibacy. For him, astronomy was a spiritual exercise, an effort to come closer to God. Whereas once upon a time, philosophers were convinced that the eyes of the whole universe were telescopically focused on their thoughts and actions (*Truth and Lies in a Nonmoral Sense*, Sect. 1), this type of self-respect (of *Achtung vor sich*) had now reverted into self-contempt (*Selbstverachtung*), so that the Copernican revolution exemplified a reevaluation of values, a slave revolt in the epistemic realm. This same theme would later be addressed by Freud (1917/1947) as the "narcissistic offense" entailed in scientific breakthroughs: the recurrent message that we are not as unique and important as we (anthropocentric, self-centred beings) tend to think. For Nietzsche, however, the humbling awareness of our cosmic insignificance, propagated by astronomy, reflects an attitude associated with manual labour and asceticism.

A strength of Nietzsche's genealogical assessment is the observation that, rather than being disinterested, research reflects and propagates a worldview. Scientific claims subliminally convey the moral attitudes and values of the researchers involved: in this case, Copernicus' sober Catholicism. Yet, from the point of view of methodological suspicion it should be pointed out that there tends to be another side to self-diminution. In the case of the Copernican revolution, for example, although it forced us to abandon our central position in the universe, we received something in return, namely the awareness that no other species is able to question appearances up to the point of replacing a geocentric system with a heliocentric one. Epistemologically speaking, this is an elevating experience, because heliocentricity confirms and reinforces the uniqueness of our position as *epistemological* animals, able to unravel the structure of the universe in all its astronomical complexities, with the help of scientific technicity, e.g. high-tech telescopes. It is *because of science*, one could argue, that scientists feel privileged and special. Whereas other species seem unaware of heliocentricity, forever imprisoned in their Umwelt of immediate sense perception, human beings (most notably: scientists as the human avant-garde) have developed the ability to dramatically broaden their horizon. Thus, narcissistic self-complacency is replaced by something more astonishing: our unique position (without precedent in nature) as epistemological subjects. While dwelling in their "little corner" (or, in the case of Copernicus, on the rooftop of a medieval building), these scientific workers effectively dismantled the Ptolemaic universe of their

<sup>11</sup> "Physiologisch nachgerechnet, ruht die Wissenschaft auf dem Gleichen Boden wie das asketische Ideal: eine gewisse Verarmung des Lebens ist hier wie dort die Voraussetzung ... der Ernst, dieses unmissverständlichste Abzeichen des ... schweren, arbeitenden Lebens" (*Genealogy of Morals* III Sect. 25).

masters, resulting not only in a magnification of the universe, but also in a significant enhancement (*Steigerung*) of their epistemic power.

Whereas Copernicus was still fairly Ptolemaic, however, both in terms of worldview and in terms of equipment, what significantly transformed astronomy was the escalating arsenal of high-tech research contrivances, beginning with early modern telescopes, i.e. the *technicity* of science. Important steps were taken precisely during Nietzsche's own era, when telescopes of enormous magnitude were built (Treccani 2014). From a Nietzschean perspective, all this should be interpreted as resentment: epistemic gratification as compensation for the low status and toiling hardships of the scientific practitioner. Again, I will come back to this, but before doing so let me discuss my third case study.

## 6 Case Study 3: Psycho-Microscopy

In his essay "A difficulty in the path of psychoanalysis", already cited above, Freud (1917/1947) mentions a third example of a narcissistic offense (a scientific breakthrough which triggers resistance because it challenges our narcissistic self-image). Besides the Copernican revolution (addressed above) and the Darwinian revolution (widely discussed in the Nietzsche literature), Freud mentions as a third example his own discovery that we are not masters in our own house, i.e. the discovery of the unconscious, for which Nietzsche is often regarded as a precursor (Ellenberger 1970; Assoun 1980). In the first section of the first essay of *Genealogy of Morals*, for instance, Nietzsche acknowledges his indebtedness to "English psychologists", whom he refers to as "microscopists of the soul" (*Mikroskopiker der Seele*, *Genealogy of Morals* Sect. 1), because these researchers dare to explore unfamiliar realms of psychic existence. Notably, they aim to reveal how moral convictions originate from automatic "molecular" reflexes. Contrary to microbial microscopists, however, a Nietzschean psychologist explores the mind via introspection.

In *Dawn of Day* (Sect. 119) we find a detailed account of Nietzsche's psychological views, predominantly developed via psychic self-exploration. All our conscious ideas, Nietzsche argues, amount to nothing but picture-speak (*Bilderrede*) and fabrication (*Erdichtung*). We are continuously interpreting the nervous stimuli (Nervenreize) we experience. Our conscious judgements and evaluations are images and phantasies based on psychic, neurological and physiological processes unknown to us. Our so-called consciousness is a more or less fantastic commentary on an unknown, and perhaps unknowable, intuited text.<sup>12</sup> Nietzsche stresses, however, that even terms like "nervous stimuli" and "text" are mere metaphors.<sup>13</sup> Every effort of science to explore these unknown neural processes is bound to result in "interpretations", "fabrications", "images" and "metaphors", i.e. strategies to incorporate the unknown by translating it into something we are familiar with.

<sup>12</sup> "All unser sogenanntes Bewusstsein [ist] ein mehr oder weniger phantastischer Kommentar über einen ungewussten, vielleicht unwissbaren, aber gefühlten Text", *Dawn of Day*, Sect. 119; cf. Müller-Lauter 1971/1999, p. 164).

<sup>13</sup> Nietzsche uses the term "metaphor" in its literal sense (to transfer, to carry over), in this case: transferring/translating a nerve stimulus into a mental image or a word, thereby "carrying it over" from the physiological into the psychological and philological domain, so that nerve stimuli become image and text (cf. Hinman 1982). In other words, a metaphor is an *interpretation* (or, as Nietzsche would argue, a falsification) of raw sense data into something recognisable and meaningful.

This reverberates with Nietzsche's account from an earlier period, concerning the questionability of scientific knowledge, namely *Truth and Lies in a Non-moral Sense* (*Über Wahrheit und Lüge im außermoralischen Sinn*), where he argues that knowledge is a human invention and basically amounts to falsification (*Verstellung, Täuschung*) and fabrication (i.e. the production of fictions, conventions and illusions). Here he already argues that we are constantly transforming nervous stimuli (*Nervenreize*) into language-images (*Sprachbilder*), metaphors (*Metaphern*) and anthropomorphisms. This not only applies to every-day thinking, moreover, for in Nietzsche's view scientific research basically amounts to the same. All knowledge depends on metaphor (Emden 2004, p. 91) and science likewise produces metaphors which gradually evolve into concepts, but we will never really reach the things out there. Our scientific method, our logic, our mathematics will never allow us to bridge the gap between human experience and raw nature. Researchers falsify the real and rectify its ambiguities with the help of images, concepts and numbers (Remhof 2015a, b, p. 236), eventually producing a whole "army of metaphors, metonyms, and anthropomorphisms". Nietzsche even considers mathematics as a humanisation of nature (Babich 2011, p. 305). All truths are illusions, and if we consider something as true, this merely means that we have forgotten how this particular illusion was brought about.

As many authors have pointed out, there is an obvious problem of self-referentiality in Nietzsche's claim, which makes it self-refuting. If Nietzsche's statement is true (that every claim about nature is interpretation), then Nietzsche's own claims should likewise be considered as interpretation, so that... And if every understanding of nature is ultimately illusory and untrue, then also Nietzsche's own understanding of nature (in terms of chaos, will to power, etc.) should be considered illusory and untrue, so that... etc. (Anderson 1999; Welshon 2009; Schliemann 2014). This tension or paradox permeates Nietzsche's thinking and continues to pose a challenge to academic readers, one that is difficult to solve, if only because Nietzsche's own views on this matter are fluid and flexible, so that we see him exploring and experimenting with various positions and possible interpretations in the course of his work. My personal approach vis-a-vis this challenge is to focus on (what I see as) Nietzsche's major contribution, namely his emphasis on the productivity of scientific knowledge. Yes, all research practices necessarily entail instances of fabrication, falsification and interpretation, but some interpretations are more productive than others. From a Nietzschean perspective, the claim that "water = H<sub>2</sub>O", for instance, is inevitably an interpretation, dependent on a particular style of reading and appropriating nature which emerged in scientific laboratories during the final decades of the eighteenth century (the Lavoisier era). It is a very productive interpretation, obviously, allowing us to domesticate and appropriate the phenomenon water and to enhance our sense of control over nature until, 1 day, an even more powerful and productive interpretation will present itself. The optimal way to come to terms with the anomalies of Nietzsche's epistemology, I would argue, is to focus on how science as an interpretative practice actually works.

To begin with, we must be aware that a scientific (i.e. experimental and quantitative) approach to psychic phenomena was emerging precisely at the time when Nietzsche was elaborating his views. In 1860, Gustav Theodor Fechner had published his elements of psychophysics (*Elemente der Psychophysik*), studying the relationship between physical stimuli and conscious sensations. In 1879, Wilhelm Wundt had founded the first psychological laboratory in Leipzig, devoted to developing a non-Cartesian psychology firmly embedded in physiology: in neural and somatic processes, in the body (Emden 2016). Fechner and Wundt represented small-scale pioneer beginnings of what today has evolved into a scholarly discourse of immense proportions. During recent decades, experimental neurophysiology developed precision technologies such as electroencephalography (EEG) and



functional magnetic resonance imaging (fMRI) to open up the enigmatic world of brain functioning on the cellular and molecular level. These technologies now purport to provide high-tech windows into Nietzsche's unknown and allegedly inaccessible *Nervenreize*. If we follow Nietzsche, however, all the knowledge claims articulated in the volumes, papers and power-points devoted to this topic still present us with nothing but metaphors. According to Nietzsche, like all human (all-too-human) knowledge, science remains imprisoned in the platonic cave (*Gefängniswänden*) of images and myths. The only way to escape from this prison, Nietzsche argues, would be by trying to imagine how insects or birds experience the world, which he considers an impossibility.

Again, a strength of Nietzsche's analysis is his sensitivity to the metaphorical dimension of scientific language, urging us to pay attention, not only to the metaphors at play, but especially to their historical and genealogical origins. At the same time, a crucial aspect of the scientific knowledge production process is consistently ignored or at least undervalued by him. Nietzsche seems to assume that scientists remain highly dependent, on the one hand on the characteristics (and limits) of human sense organs, and on the other hand on the metaphorical nature of human language. Unlike what Nietzsche seems to suggest, however, scientists (precisely *because* they share his suspicious attitude towards natural sense organs and "natural" languages) tend to *outsource* activities such as observation, interpretation and analysis to precision instruments (sometimes functioning as electronic "insects" if you like, with completely different eyes and signalling networks than ours). What Nietzsche seems to ignore is precisely the *technicity* of modern technoscience. Rather than relying on natural sense organs (on our organic retinas, our taste receptors, etc., as products of *natural* evolution), scientists develop a plethora of contrivances to provide them with quantitative, high resolution images of the world (as products of *technological* evolution), disclosing aspects which humans would never have discerned with their natural senses (Schliemann 2014, p. 69).

I am not at all suggesting of course that these technical images produced by science provide us with a final objective "truth" about the world. Quite the contrary: they are technologically fabricated, so that these contrivances allow scientists to produce *knowledge* rather than *truth*. Still, we should acknowledge that these images and representations fabricated by science differ considerably from what our natural sense organs have to offer. These contrivances often function like electronic insects, revealing dimensions which unaided human sensitivity would fail to grasp. High-tech and highly sensitive contrivances for handling, modifying, manipulating and measuring natural objects increasingly marginalise or even by-pass our natural (physiological) knowledge sources and the organic exigences implied in them (Babich 1994, p. 6). Experimental science still produces images, pictures and interpretations, certainly, and yes, PowerPoint images of cells, planets or neural networks still use colour patterns (wavelength frequencies) which human eyes can recognise, but the epistemic scope and reach of science is no longer restricted by the natural filters and limits of our "naked" bodies, so that technoscience allows us to carefully explore what (until recently) would have been too small, too large or too intimately hidden.

This does not mean that images or metaphors (Big Bang, double helix, black holes, neural networks, etc.) no longer play a role in science. What it means is that the specificity of science (and this includes: the specific nature of scientific metaphors) can only be grasped if the epistemological rupture entailed in the technicity of science (i.e. the role of experimental contrivances for extending, correcting and amplifying human sensitivity) is duly acknowledged. And this requires that science is not only regarded as a text or discourse, but also as a (technological, menial) *praxis*.

Something similar applies to language, where Nietzsche seems to underestimate the capacity of science to produce artificial neo-languages, ideally even decidedly formal ones, such as the alphabets of mathematical or chemical symbols, or the nucleotide alphabet (A, C, G, T), or the digital alphabet (0, 1, 0, 1) of computer programs. Should philosophers of science discard all knowledge claims emerging from scientific research practices as mere “metaphors” or “language-pictures”, they would be making life too easy for themselves. An important feature of modern science is its insistent effort to replace the dependency of knowledge production on natural sense organs and natural languages by a new kind of dependency, namely on technicity: on technological tools and the technical languages (often highly formalised) connected with them (Schiemann 2014, p. 51). To assess scientific knowledge production from a philological perspective, as Nietzsche purports to do, we should acknowledge what Gaston Bachelard referred to as the *iconoclastic* tendency of science (Bachelard 1938/1970, p. 77; 1953, p. 122), i.e. the efforts, embedded in scientific technologies and methodologies, to obliterate the imaginative and metaphorical dimension of human experience. Bachelard emphasises how modern science, as a highly technical laboratory pursuit, actively *transforms* nature into something abstract, such as bio-chemical molecules, represented with the help of chemical symbols and mathematical equations. This will never completely eliminate the imaginary and the metaphorical as such, of course, and modern science is actually a prolific producer of images (the Big Bang, the double helix, etc.), but again: when it comes to understanding the specificity of scientific imagination, the extent to which science manages to move beyond the natural human aptitude for the metaphorical and the phantasmagorical should be explicitly acknowledged.

In order to grasp the specificity of the grammars of science, philosophers should pay due attention to the iconoclastic impetus at work in science, which is closely related to technicity and quantification. Although Nietzsche does speak about numbers and quantification, he again sees it as something which functions in service of (and remains fundamentally dependent on) the interpretations and metaphors we employ.<sup>14</sup> Quantification is one of the techniques we use to falsify the world, he argues, forcing nature to comply with our army of images. Such claims, however, are difficult to uphold as soon as we enter the laboratories of contemporary technoscience. Here, the dynamical relationship between quantification and verification (or refutation), proves a more taxing, unpredictable, interactive, dialogical and hazardous process than terms such as fabrication, assimilation and rectification suggest.

A strength of the Nietzschean approach is the suspicious sensitivity towards metaphors at work, even (or especially) in apparently abstract and technical forms of scientific discourse. In order to make this type of analysis more relevant and revealing, however, the Nietzschean “pathos of distance” should be replaced with a *pathos of proximity*. Philosophers of science should familiarise themselves with science as a *practice*, with the ways in which scientific research is actually conducted, notably with the technicity at work in the context of discovery. Since Nietzsche’s reflections in the 1880s, technoscience has been disclosing the inaccessible and the concealed, has allowed us to leave the chamber of consciousness (*Bewusstseinszimmer*), where philosophers such as Descartes and Berkeley were still imprisoned. And this has been achieved not only by providing access to nervous stimuli and neural networks, but also by disclosing what Nietzsche refers to as the most

<sup>14</sup> “For Nietzsche, the Western valuation of calculative efficacy is no more than an illusion... a dissembled interpretation” (Babich 1994, p. 6); scientific truth is “a world-making interpretation” (p. 15); physics is an “arrangement”, not an “explanation” of the world (p. 37).

hidden from us: the secrets of our bowels,<sup>15</sup> for with the help of high-throughput sequencing machines, microbiology currently analyses how not only human health and well-being, but also human cognition is significantly influenced and nurtured by our gut microbiota, the microbiome as our “forgotten organ”, our “collective unconscious” (Dinan et al. 2015).

Thus, in order to be convincing, a Nietzschean philosophy of science would require an attitude of proximity, dialogue and interaction. A Nietzschean philosopher of science should not rely solely on libraries or Alpine walks, but should visit laboratories, trawling through the files, first and foremost the primary (technical) literature, precisely to study as closely as possible the ways in which scientific knowledge is *fabricated*. In other words, to be convincing, a Nietzschean philosophy of science requires *hard work*.

## 7 Basic Ingredients of a Nietzschean Philosophy of Contemporary Technoscience

In the Nietzsche scholarship, three periods are commonly distinguished (Abbey 2000, p. xii), namely: early writings (1869–1876, from *The Birth of Tragedy* up to *Untimely Meditations*); a middle period (1876–1882, from *Human, All-Too-Human* up to *The Gay Science*) and a later period (1883–1888; from *Thus Spoke Zarathustra* via the *Beyond Good and Evil* and *On the Genealogy of Morals* up to *Twilight of the Idols*, *Anti-Christ* and *Ecce Homo*).<sup>16</sup> From one period to the next, Nietzsche’s attitude towards natural science tended to change. In *The Birth of tragedy*, for instance, science and rationality (represented by Socrates) are regarded as antithetical to life and culture (Brobjer 2004, p. 29), but during the middle period, Nietzsche opts for a more positive stance, seeing science and rationality as iconoclastic allies of Enlightenment, supportive of the effort to cleanse the world of religious chimeras. It is during this period that Nietzsche actually begins to *read* science (albeit not as “exclusively” as he later claimed: Brobjer 2004, p. 35). His “chemistry of concepts and sensations” becomes a cathartic cure (Large 2004, p. 189), a release from philology (p. 190);—albeit not from philology as such, as we have seen, but from classical philology, replacing it by the ambition to flesh out a philological assessment of his own nineteenth-century, German, bourgeois culture.

During the third period, however, Nietzsche becomes more critical of science again, although his position remains fairly ambiguous. On the one hand, he proposes to “translate human beings back into nature” [Den Menschen [...] zurückübersetzen in die Natur] (*Beyond Good and Evil*, Sect. 230); cf. Ward 2011, p. 125), a vocation which may be seen as concurrent with the program of natural science. At the same time, he reverts to a position of scepticism and suspicion,<sup>17</sup> regarding all scientific concepts as fictions. Science is assessed in terms of fabrication, falsification and the will to power, as we have seen. Whereas nature stands for chaos and chance events (Schlechta 1969, III, p. 1439), the aim of science is to enforce its laws and predictions on natural phenomena, via rectification

<sup>15</sup> “Was weiß der Mensch eigentlich von sich selbst! ... Verschweigt die Natur ihm nicht das allermeiste, selbst über seinen Körper, um ihn, abseits von den Windungen der Gedärme, in ein stolzes gauklerisches Bewusstsein zu bannen und einzuschließen! (*Truth and Lies in a Non-Moral Sense*, Sect. 1)”.

<sup>16</sup> These three periods are flanked as it were by his (“pre-philosophical”) papers and publications on classical philology (notably on Democritus, Diogenes Laertius and Homer) and his *Nachlass*.

<sup>17</sup> “Nietzsche misstraut zutiefst den begrifflichen Mitteln, mit denen Wissenschaftler ... bisher versuchten, die Wirklichkeit einzufangen, abzubilden oder zu erklären.” (Fischer 2011, p. 437).

(*Zurechtmachung*), thereby misrepresenting the real Democritean cosmic whirl or Heraclitean flux (Brown 2004, p. 68). His final writings from this period tend to swing towards a more affirmative view on science again, however.<sup>18</sup> Most assessments of Nietzsche's philosophy of science (including this paper) tend to focus on the latter period, but as a third moment, evolving against the backdrop of his previous positions. The boundaries between these periods tend to be somewhat fluid, moreover. *Truth and Lies in a Non-moral sense*, for instance, although belonging to his earlier writings (dating from 1873), anticipates many of his later views in terms of content.

Whereas in his earlier writings Nietzsche's style of thinking remains predominantly philological, during his middle period he claims to adopt a more scientific stance. Optimally, his aim now is to replace philology by physiology and chemistry, as we have seen. For a Nietzschean philosophy of science, however, his third period is the most decisive one. During this period, he develops what was referred to above as a *philological* critique of science, focussing on philological concerns such as interpretation, falsification, genealogy and metaphor. In other words, his critical, diagnostical instruments (his reflex hammer, stethoscope, magnifying glass etc.) which he uses to evaluate physiology, chemistry, astronomy, evolutionary theory, etc., are borrowed from philology,<sup>19</sup> but applied to scientific discourse.

Take for instance interpretation, a philological practice which, in Nietzsche's later writings, is extrapolated into a universal process. Interpretation now becomes a symptom of the will to power (Baek 1997, p. 20) in the sense that *all* beings (both human and non-human) continuously interpret the world in accordance with their vital interests, so as to enhance their sense of power and control. These interpretations are continuously and actively enforced upon the Heraclitean-Democritean turbulence. For Nietzsche, interpretation is first and foremost a bodily (physiological, neuro-physiological) phenomenon moreover (Emden 2016). Our interpretations are produced by our bodies, rather than by our minds. Interpretation basically is an effort to humanise the world (Baek 1997, p. 196), to force reality to appear in such a way that we may physiologically deal with it. Interpretation is appropriation, assimilation, incorporation and rectification of otherness.

This view on interpretation is extrapolated to modern science. In other words, natural science itself becomes naturalised by Nietzsche. Laws are not discovered, but enforced (Müller-Lauter 1971/1999, p. 147), nature's conformity to laws is interpretation, as we have seen, and eventually *all* scientific knowledge is interpretation (p. 148). The will to power *is* interpretation, for interpretation is our means of mastering something. Organic processes themselves are interpretations (assimilations, adjustments, incorporations, etc., p. 149). In short, all existence = will to power = interpretation. The world-process itself is interpretative (Babich 1994, p. 43) and science participates in a cosmic interpretative struggle. Nietzsche's philosophy of science is a "genealogy of objectivity" (Müller-Lauter 1971/1999, p. 62), starting from the conviction that scientific knowledge claims are interpretations, not matters of fact; exegesis, not explanation (Babich 1994, p. 37).

<sup>18</sup> "Nietzsche expresses critique of science, and he is frequently interpreted as an opponent and critic of science. However, when we turn to the published works from his last active year, 1888, the picture we get is very different. There he is overwhelmingly positive to science, even while expressing critique and ambivalence" (Brobjer 2011, p. 39).

<sup>19</sup> "Die einzige Disziplin, in der er selbst eine solide Ausbildung erfahren hat, die klassische Philologie, sensibilisiert ihn für die kulturhistorische Komponente des ... epistemischen Wandels und bleibt von Grundlegender Bedeutung für sein Wissenschaftsverständnis" (Heit and Heller 2014a, b, p. 2).

Yet precisely here, I would argue, to be convincing to non-adepts, a Nietzschean philosophy of contemporary technoscience requires something more. If we concede that a scientific understanding of the world amounts to interpretation (in the Nietzschean sense of the term), science nonetheless constitutes an interpretative praxis *sui generis*. The experimental method, enabled by and contributing to the technicity of science, allows scientists to modify and interpret the world in completely new ways, challenging established (metaphysical) worldviews and significantly transcending the boundaries of bodily interpretations. Scientific interpretation is decidedly an interactive (experimental) process, and scientific techniques are developed to intensify our interactions with nature, unleashing unprecedented sequences of stimulus and response, thus significantly enhancing our interpretative power. More than ever, we now seem able to interpret and modify nature in accordance with our interests and desires, up to the point of disrupting eco-systems on a global scale and producing wholly new life forms in vitro (neo-life).

From a Nietzschean (genealogical) perspective, this technoscientific capacity for nature-modification (transforming science into technoscience, biology into biotechnology, etc.) may still be interpreted as a compensation for our weakness and as a symptom of resentment no doubt (Babich 1994, p. 188). For Nietzsche as a genealogist, rather than indicating genuine strength and mastery, scientific manipulations (however effective) continue to betray the humble, manual, ascetic, lower-class origins of its practitioners. He “delights” in their hard work, as we have seen, but condescendingly looks down upon these toiling workers in their smoky little corners (*Genealogy of Morals III*, Sect. 23). Instead of achieving the self-mastery and natural authority characteristic of the aristocratic Master, the “scientific type” attains power through the force of ascetic interpretations, which purport to discover unchangeable laws in nature (Johnson 2010, p. 196).

This line of reasoning, however, is questionable, as we have seen. First of all, in order to be convincing, such assessments require elaborate and precise justifications, in other words: substantial amounts of scholarly hard work, working through the case histories and archives of science. It would require a shift in genre from impromptu observations, captured in elegant aphorisms, to extensive academic analyses. Nietzsche is not necessarily critical of such work. In *The Gay Science* Sect. 7, for instance, he envisions immense areas of work, waiting to be explored by “the industrious”: those who are really willing to study human society and its history from a genealogical perspective. Nietzsche’s aim is not to become such an industrious worker himself, however. Rather, we have to wait for scholars such as Michel Foucault who, inspired by Nietzsche, really took up this summons and immersed himself in archives. Still, this type of work involves toiling in libraries, on the basis of accurate and suspicious reading: philology rather than physiology. As a result, Nietzsche and/or the Nietzscheans underestimate the extent to which scientific insights stem from *active interactions* with nature, from physical labour, conducted in laboratories, rather than in libraries. Whereas the verb “interpretation” seems connected with intellectual activities such as reading or contemplation, scientific research involves *facere* and *fin-gere*, in other words: more active, menial and productive types of intellectual activity. This is even more pertinent when it comes to addressing contemporary technoscience, which became so astonishingly successful, not only in interpreting, but also in actively modifying nature.

In a contribution to one of the Nietzsche and science volumes, two forms of aristocratic knowledge formation are confronted with one another, namely the contemplative knowledge ideal of the aristocratic master (Parmenides, Plato, Plotinus, etc.) versus the experimental knowledge ideal of the alchemist-magician (Allen 1999). The latter for a long time had remained an experimental undercurrent, Allen argues, but rose to the surface during

the early modern epoch and contributed significantly to the scientific revolution. What is obfuscated in this genealogy (connecting modern science with magic and alchemy), however, is that the experimental method can also be seen as an off-spring of a third (albeit decidedly less aristocratic) source of insight and experience, whose importance was emphatically acknowledged (for the first time in Western history perhaps) by Hegel in his dialectics of the Master and the Servant, namely manual (agricultural and artisanal) labour, not as a source of (exploitable) value, but first and foremost as a source of (experimental, experiential and technical) knowledge, as a way of being-in-the-world, a way of life, resulting in a view of nature which differed significantly from the contemplative Master's view (Zwart 2009). There is an important genealogical continuity between the daily toiling of farmers and craftsmen (since the dawn of the Neolithic revolution, in combination with the continuous enhancement and refinement of effective tools this entailed) and the menial work of experimental researchers in their laboratories (literally: workshops or knowledge factories). Whereas there is a long tradition within philosophy of looking down upon the value of this type of knowledge in a derogatory fashion (from Plato up to Nietzsche), more recent thinkers (Hegel, Marx, Serres, etc.) have emphasised the value of this practical source of insight, not only because it produces robust and valuable knowledge, but also because it may serve as a therapeutic antidote for aristocratic intellectualism (the type of knowledge produced by leisure classes). In countless experimental practices involving researchers from the "lower" classes [e.g. thermodynamics, a field which emerged in response to the development of steam engines, or Mendel's experiments, which entailed a quantification and experimental systematisation of practices of horticulture: Zwart (2008a, b)], this genealogy is evidently noticeable. The manual tradition of hands-on thinking has its own criteria of validity, moreover, namely whether certain interpretations work, yielding outcomes which foster life and enhance sensitive control over the environment. From a genealogical perspective, manual interactivity should not be regarded as practical or technical in the "applied" sense of the term, but as a revealing, alethic practice in its own right, which allows us to experience nature in a specific manner, while allowing nature to appear in a certain way, disclosing dimensions of nature (the quantum world of quantum physics, the microbial world of microbiology, the spacetime universe of astrophysics, etc.) of which we would be utterly unaware should we rely solely on reading and contemplation. I highlight this because precisely this manual, interactive aspect of laboratory research, resulting in high precision experimental interaction, seems underrepresented in Nietzsche's interpretation of science.

## 8 Conclusion

A strength of Nietzsche's philosophy of science, I argued, lies in his methodical sensitivity to the role of interpretation, his genealogical-philological approach, highlighting the history of scientific terms as well as the metaphors at work in scientific *discourse*. As a philologist, Nietzsche reads texts in a sceptical, distrustful manner, paying close attention to apparently insignificant details,<sup>20</sup> in order to discern the "machinations of power" (Acampora 2004, p. 178), the "anthropomorphising of nature and life" (p. 180). In *Genealogy of*

<sup>20</sup> "Das scheinbar unwichtigste sprachliche, metrische, paläografische Detail konnte den Schlüssel zum Erfolg darstellen" (Benne and Santini 2014, p. 178).

*Morals* and *Anti-Christ* he emphasises that it is no coincidence that, in Hellenistic Alexandria, medicine and grammar emerged simultaneously, because both the philologist and the physician knew how to immunise themselves (professionally) against ideological pandemics caused either by biological pathogens or by infectious religious texts (*Anti-Christ* 47; Benne and Santini 2014, p. 194). Nietzsche sees himself as a *philologist* who is at the same time a *physician* of culture, self-inoculated against asceticism. Scientific discourse must be scrutinised in a careful and *symptomatic* manner, in order to detect the fabrications, falsifications, adaptations and deletions at work there. In line with this, his chemistry of concepts intends to reveal the base and down-to-earth origins of lofty ideas. Instead of being disinterested, scientific discourse is scarred and tainted by vital interests. This is a key Nietzschean insight which evolves into the conviction that the scientific will to know is not driven by curiosity but fuelled by the will to power. In short, Nietzsche's reading strategy aims to be more critical, more iconoclast, more radical in its scepticism even, than science itself.

For Nietzsche, moreover, science remains an anthropomorphic endeavour, entailing a *humanisation* of nature. Yes, scientists are sceptics, but scientific scepticism represents a "weak" or "ascetic" type of scepticism which Nietzsche aims to overcome. According to Nietzsche, science is only able to uphold its practice of negating and renouncing questionable claims because of the promise of compensation and reward (in the form of insights and recognition) which awaits the toiling, suffering researcher at the end of the tunnel. This contrasts with strong or grand scepticism as Nietzsche sees it, i.e. the creative affirmation of the absence of truth (Van Tongeren 1999). In other words, Nietzsche sees science as a practice which turns life into an ascetic procedure (Owen 1999).

A deficiency in Nietzsche's assessments, I argued, is his lack of appreciation of the technicity of science, the workings of science as a *praxis*, e.g. the outsourcing of operations such as observation, interpretation and analysis to sensitive machines and its implications for the structure of scientific practice and scientific discourse. This outsourcing of knowledge production to technicity is undertaken precisely in order to decrease the dependency of knowledge on us as "embodied, prejudiced, historical knowers" (Babich 1999, p. 5) and to drastically eliminate the anthropomorphic biases and contaminations. I do not claim, of course, that science no longer represents a human enterprise, or that science has become perfectly "immaculate" (Babich 1999, p. 5; Schacht 1999, p. 34). What I mean is that, yes, scientific interpretations are contaminated by human interests, idols and anthropomorphisms, but often in *very specific ways*, and these deserve to be addressed in a careful manner, namely by studying, in a precise and detailed fashion (via symptomatic case histories), how science is practiced and how scientific insights are actually fabricated. From a genealogical perspective, knowledge is inherently embodied and anthropomorphic, but given the technicity of present-day technoscience (and the decentralisation or even marginalisation of the scientific embodied subject this implies), the claim that science should still be regarded as a "discipline of the body" (Babich 1999, p. 8), although in principle still valid, is in need of a more precise and tailored diagnostics.

The first case study (experimental physiology) indicated that a Nietzschean approach to science should indeed be sensitive to the basic images and metaphors at work, in this case the archetypal image of the animal-machine. What we found lacking in Nietzsche's analysis, however, was the recognition that, from the very outset, this metaphor was challenged, and soon became questionable or even untenable, due the practical interactions of physiologists with living animals, who responded as sensitive organisms to experimental stimuli, rather than as insensitive machines. This practical, experiential dimension seems obfuscated in Nietzsche's reading of the case.

In the second case study (Copernican astronomy), Nietzsche regards self-diminution as symptomatic for the attitude of asceticism pervading modern science. Again, the focus is on the discursive dimension, where the basic displacement (of *geo*-centrism by *heliocentrism*) challenges the narcissistic self-centredness of the ancient astronomers, who conducted their research unaided: with the naked eye. What remains underacknowledged, I argued, is that, on the practical level, modern astronomers developed increasingly powerful tools which allowed them to effectively dwarf the universe of the ancients, resulting in an enhancement (*Steigerung*) of epistemic power, rather than in humility.

In the third case study I indicated that technoscience, rather than obfuscating the body, effectively allows us to descend into its molecular depths, from brain to gut, in order to analyse how psychic phenomena actually build on and are fed by neural, somatic and metabolic processes. This awareness of the technicity of science does not render a Nietzschean approach irrelevant, far from it, but in order to critically assess the images and metaphors, the fabrications and falsifications, the desires and interests at work in contemporary technoscience, Nietzsche's philological instruments should acknowledge the specificity of scientific knowledge production as a practice *sui generis* compared to experiences emerging in every-day settings (formatted by the functioning of natural sense organs and framed by socio-cultural expectations embedded in natural languages). An awareness of the formatting and framing at work in scientific research practices, however, requires a pathos of proximity, a willingness on the part of philosophers of science to familiarise themselves with the vicissitudes of laboratory life, with the functioning of laboratories as ecosystems of knowledge production.<sup>21</sup>

Allow me to give a concrete example, involving the cell-concept, one of the key concepts of contemporary life sciences research. Philosophers of science, following in Nietzsche's footsteps, should first of all pay attention to the metaphorical and etymological origins of the term, which tends to be obfuscated in mainstream scientific discourse. An etymological/genealogical investigation will inform them that the term cell was first used by Robert Hooke in his science classic *Micrographia*. The cells which he spotted in cork through his microscope, reminded him of the rooms of monks in a monastery. So, yes, "cell" is evidently a metaphor, and even contaminated with a tinge of monastic asceticism. This, however, can only be the first step. Subsequently it should be acknowledged that, in contemporary life sciences laboratories, the cell concept evolved into something completely different. A dramatic reversal has taken place. The cell seems to have shed its ascetic heritage, and current understandings reflect a revaluation of values. For whereas the monastic cell image suggests a sealed, cramped, empty, silent, inactive location, the cells that are studied by contemporary technoscience today are highly active, interactive and semi-transparent laboratory-like structures, vibrant and full of life, plastic and adaptive (Zwart 2018). In other words, our sensitivity to metaphors should reveal how metaphors evolve. This, however, requires a pathos of proximity, a willingness to visit laboratories and to familiarise ourselves, not only with the *texts* of science (science as discourse), but also with the *technicity* of science (science as a challenging, frustrating, taxing, fascinating,

<sup>21</sup> My criticism of Nietzsche concurs with Don Ihde's criticism of Husserl who, by focussing on conceptualisation and mathematization, while ignoring Galileo's telescope, underemphasized the role of instruments as mediators of sense perception, thereby obfuscating the practical, interactive and experiential dimensions of scientific work: in other words, ignoring the extent to which concrete manual research practices (e.g. land surveying and other practices of measurement) remain part of the revelatory, alethic power of modern science as a *practice* up to this day (Ihde 2011).



revealing, etc. praxis). Proximity will not necessarily result in a positive valuation, for indeed, as Babich (1994) argues, from a Nietzschean perspective, the calculative efficacy of technoscience may prove illusive, its computational models anti-aesthetical, its methodologies self-advancing, but still, such an approach will generate a more precise understanding of the specific nature of scientific interpretations. The results will be a probing, tentative, interpretative, questioning and gay endeavour, assessing science from an “oblique” perspective (Babich 1994; Zwart 2017b), historically and linguistically informed, focussing on symptomatic case histories, but preferably in close dialogue with practitioners of science themselves.

## Compliance with Ethical Standards

**Conflict of interest** The author has no conflict of interests.

**Open Access** This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

## References

- Abbey, R. (2000). *Nietzsche's middle period*. Oxford: Oxford University Press.
- Acamora, C. (2004). Between mechanism and teleology: Will to power and Nietzsche's gay 'science'. In G. Moore & T. Brobjer (Eds.), *Nietzsche and science* (pp. 171–188). Aldershot/Burlington: Ashgate.
- Allen, B. (1999). All the daring of the lover of knowledge is permitted again. In B. Babich (Ed.), *Nietzsche, epistemology, and philosophy of science: Nietzsche and the sciences II* (pp. 123–140). Dordrecht/Boston/London: Kluwer.
- Anderson, R. L. (1999). Nietzsche's views on truth and the Kantian background of his epistemology. In B. Babich (Ed.), *Nietzsche, epistemology and philosophy of science. Nietzsche and the Sciences II* (pp. 47–59). Dordrecht/Boston/London: Kluwer.
- Anderson, R. L. (2011). The will to power in science and in philosophy. In H. Heit, G. Abel, & M. Brusotti (Eds.), *Nietzsches Wissenschaftsphilosophie: Hintergründe, Wirkungen und Aktualität* (pp. 55–72). Berlin/Boston: De Gruyter.
- Andresen, J. (2013). Nietzsche, naturalism, and falsification. *The Journal of Nietzsche Studies*, 44(3), 469–481.
- Aquinas, T. (1922). *Summa Theologica*. Taurini: Marietti.
- Assoun, P.-L. (1980). *Freud et Nietzsche*. Paris: Quadrige/PUF.
- Babich, B. E. (1994). *Nietzsche's philosophy of science: Reflecting science on the ground of art and life*. Albany: State University of New York Press.
- Babich, B. (Ed.). (1999a). *Nietzsche, epistemology and philosophy of science. Nietzsche and the Sciences II*. Dordrecht/Boston/London: Kluwer.
- Babich, B. (1999b). Truth, art and life: Nietzsche, epistemology, philosophy of science. In B. Babich (Ed.), *Nietzsche, epistemology and philosophy of science. Nietzsche and the Sciences II* (pp. 1–24). Dordrecht/Boston/London: Kluwer.
- Babich, B. (2011). Nietzsches hermeneutische, phänomenologische Wissenschaftsphilosophie. Unzeitgemäße Betrachtungen zu Althilologie und Physiologie. In H. Heit, G. Abel, & M. Brusotti (Eds.), *Nietzsches Wissenschaftsphilosophie: Hintergründe, Wirkungen und Aktualität* (pp. 291–314). Berlin/Boston: De Gruyter.
- Bachelard, G. (1938/1970). *La formation de l'esprit scientifique: Contribution à une psychanalyse de la connaissance objective*. Paris: Vrin.
- Baek, S. Y. (1997). *Interpretation bei Nietzsche: eine Analyse*. Würzburg: Königshausen und Neumann.

- Benne, C., & Santini, C. (2014). Nietzsche und die Philologie. In H. Heit & L. Heller (Eds.), *Handbuch Nietzsche und die Wissenschaften: Natur-, geistes- und sozialwissenschaftliche Kontexte* (pp. 173–200). Berlin/Boston: De Gruyter.
- Borsche, T. (2011). Wozu Wissenschaft? Überlegungen zu Fragen der Rangordnung im Wissenschaftsdiskurs nach Nietzsche. In H. Heit, G. Abel, & M. Brusotti (Eds.), *Nietzsches Wissenschaftsphilosophie: Hintergründe, Wirkungen und Aktualität* (pp. 465–480). Berlin/Boston: De Gruyter.
- Brobjer, T. (2004). Nietzsche's reading and knowledge of natural science. In G. Moore & T. Brobjer (Eds.), *Nietzsche and science* (pp. 21–50). Aldershot/Burlington: Ashgate.
- Brobjer, T. (2011). Nietzsche's last view of science. In H. Heit, G. Abel, & M. Brusotti (Eds.), *Nietzsches Wissenschaftsphilosophie: Hintergründe, Wirkungen und Aktualität* (pp. 39–54). Berlin/Boston: De Gruyter.
- Brown, R. (2004). Nietzsche: That profound physiologist. In G. Moore & T. Brobjer (Eds.), *Nietzsche and science* (pp. 51–70). Aldershot/Burlington: Ashgate.
- Dahlkvist, T. (2014). Nietzsche and medicine. In H. Heit & L. Heller (Eds.), *Handbuch Nietzsche und die Wissenschaften: Natur-, geistes- und sozialwissenschaftliche Kontexte* (pp. 138–154). Berlin/Boston: De Gruyter.
- Dinan, T., Stilling, R., Stanton, C., & Cryan, J. (2015). Collective unconscious: How gut microbes shape human behaviour. *Journal of Psychiatric Research*, 63, 1–9.
- Drenthen, M. (2002). Nietzsche and the paradox of environmental ethics: On the concept of nature within Nietzsche's critique of morality. *New Nietzsche Studies*, 5(Issue ½), 12–25. <https://doi.org/10.5840/newnietzsche200251/22>.
- Ellenberger, H. F. (1970). *The discovery of the unconscious*. London: Lane/Penguin.
- Emden, C. (2004). Metaphor, perception and consciousness: Nietzsche on rhetoric and neurophysiology. In G. Moore & T. Brobjer (Eds.), *Nietzsche and science* (pp. 91–110). Aldershot/Burlington: Ashgate.
- Emden, C. (2016). Nietzsche's will to power: Biology, naturalism, and normativity. *The Journal of Nietzsche Studies*, 47(1), 30–60.
- Fischer, N. (2011). Nietzsches Wissenschaftsphilosophie: Struktur, Wurzeln, Wirkungen. In H. Heit, G. Abel, & M. Brusotti (Eds.), *Nietzsches Wissenschaftsphilosophie: Hintergründe, Wirkungen und Aktualität* (pp. 437–454). Berlin/Boston: De Gruyter.
- Freud, S. (1917/1947). Eine Schwierigkeit der Psychoanalyse. In S. Freud (Ed.), *Gesammelte Werke XII* (pp. 3–12). London: Imago.
- Gaukroger, S., et al. (Eds.). (2000). *Descartes' natural philosophy*. London: Routledge.
- Grayling, A. C. (2006). *Descartes*. London: Simon and Schuster.
- Heit, H. (2011). Ein Problem mit Hörnern—Nietzsche als Wissenschaftsphilosoph. In H. Heit, G. Abel, & M. Brusotti (Eds.), *Nietzsches Wissenschaftsphilosophie: Hintergründe, Wirkungen und Aktualität* (pp. 5–24). Berlin/Boston: De Gruyter.
- Heit, H. (2014). Nietzsches Philosophie und das 'Age of Science'. In H. Heit & L. Heller (Eds.), *Handbuch Nietzsche und die Wissenschaften: Natur-, geistes- und sozialwissenschaftliche Kontexte* (p. 19–4). Berlin/Boston: De Gruyter.
- Heit, H., Abel, G., & Brusotti, M. (Eds.). (2011). *Nietzsches Wissenschaftsphilosophie: Hintergründe, Wirkungen und Aktualität*. Berlin/Boston: De Gruyter.
- Heit, H., & Heller, L. (Eds.). (2014a). *Handbuch Nietzsche und die Wissenschaften: Natur-, geistes- und sozialwissenschaftliche Kontexte*. Berlin/Boston: De Gruyter.
- Heit, H., & Heller, L. (2014b). Nietzsches Philosophie und das 'Age of Science'. In H. Heit & L. Heller (Eds.), *Handbuch Nietzsche und die Wissenschaften: Natur-, geistes- und sozialwissenschaftliche Kontexte* (pp. 1–6). Berlin/Boston: De Gruyter.
- Heller, L. (2014). Ausführliche Inhaltsübersicht. In H. Heit & L. Heller (Eds.), *Handbuch Nietzsche und die Wissenschaften* (pp. 7–16). Berlin/Boston: De Gruyter.
- Hinman, L. (1982). Nietzsche, Metaphor, and Truth. *Philosophy and Phenomenological Research*, 43(2), 179–199.
- Hossain, A. (2013). Between concept and metaphor: Reviewing Nietzsche's doctrine of Truth. *International Journal of Philosophy*, 1(1), 6–20. <https://doi.org/10.11648/j.ijp.20130101.12>.
- Inde, D. (2011). Husserl's Galileo needed a telescope. *Philosophy and Technology*, 24(1), 69–82.
- Janz, C. P. (1978). *Friedrich Nietzsche: Biographie (three volumes)*. München/Wien: Hanser Verlag.
- Johnson, D. (2010). *Nietzsche's anti-Darwinism*. Cambridge/New York: Cambridge University Press.
- Knight, D. (1986). *The age of science: The scientific world view in the nineteenth century*. Oxford: Blackwell.
- Large, D. (2004). Nietzsche's conceptual chemistry. In G. Moore & T. Brobjer (Eds.), *Nietzsche and science* (pp. 189–196). Aldershot/Burlington: Ashgate.

- MacIntyre, A. (1999). Preface. In B. Babich (Ed.), *Nietzsche, epistemology and philosophy of science. Nietzsche and the sciences II* (pp. xv–xvii). Dordrecht/Boston/London: Kluwer.
- McCance, D. (2013). *Critical animal studies: An introduction*. Albany: State University of New York Press.
- Meyer, M. (2011). Nietzsche's naturalism and the falsification thesis. In H. Heit, G. Abel, & M. Brusotti (Eds.), *Nietzsches Wissenschaftsphilosophie: Hintergründe, Wirkungen und Aktualität* (pp. 135–148). Berlin/Boston: De Gruyter.
- Mittasch, A. (1952). *Friedrich Nietzsche als Naturphilosoph*. Stuttgart: Kröner.
- Moore, G. (2002). *Nietzsche, biology and metaphor*. Cambridge: Cambridge University Press.
- Moore, G. (2004). Introduction. In G. Moore & T. Brobjer (Eds.), *Nietzsche and science* (pp. 1–17). Aldershot/Burlington: Ashgate.
- Moore, G., & Brobjer, T. (Eds.). (2004). *Nietzsche and science*. Aldershot/Burlington: Ashgate.
- Müller-Lauter, W. (1971/1999). *Nietzsche: His philosophy of contradictions and the contradictions of his philosophy*. Urbana & Chicago: University of Illinois Press.
- Nietzsche, F. (1878/1980). Human, All too human/Menschliches, Allzumenschliches I. In G. Colli & M. Montinari (Ed.), *Sämtliche Werke III. Kritische Studienausgabe*. München/Berlin/New York: DTV/De Gruyter.
- Nietzsche, F. (1881/1980). Morgenröte/Dawn of Day. In G. Colli & M. Montinari (Ed.), *Sämtliche Werke III. Kritische Studienausgabe*. München/Berlin/New York: DTV/De Gruyter.
- Nietzsche, F. (1886/1980). Jenseits von Gut und Böse/Beyond Good and Evil. In G. Colli & M. Montinari (Ed.), *Sämtliche Werke V. Kritische Studienausgabe*. München/Berlin/New York: DTV/De Gruyter.
- Nietzsche, F. (1887/1980). Genealogy of morals. In G. Colli & M. Montinari (Ed.), *Sämtliche Werke V. Kritische Studienausgabe*. München/Berlin/New York: DTV/De Gruyter.
- Nietzsche, F. (1980). *Sämtliche Werke*. In G. Colli & M. Montinari (Eds.), *Kritische Studienausgabe*. München/Berlin/New York: DTV/De Gruyter.
- Owen, D. (1999). Science, value and the ascetic ideal. In B. Babich (Ed.), *Nietzsche, epistemology and philosophy of science. Nietzsche and the Sciences II* (pp. 169–177). Dordrecht/Boston/London: Kluwer.
- Porter, J. (2000). *Nietzsche and the philology of the future*. Stanford: Stanford University Press.
- Remhof, J. (2015a). Overcoming the conflict of evolutionary and naturalised epistemology in Nietzsche. *History of Philosophy Quarterly*, 32(2), 181–194.
- Remhof, J. (2015b). Nietzsche's conception of truth: Correspondence, coherence, or pragmatist? *The Journal of Nietzsche Studies*, 46(2), 229–238.
- Remhof, J. (2016). Scientific fictionalism and the problem of inconsistency in Nietzsche. *Journal of Nietzsche Studies*, 47(2), 238–246.
- Reuter, S. (2014). Nietzsche und die Sinnesphysiologie und Erkenntniskritik. In H. Heit & L. Heller (Eds.), *Handbuch Nietzsche und die Wissenschaften* (pp. 79–106). Berlin/Boston: De Gruyter.
- Richardson, J. (2011). Nietzsche's psychology. In H. Heit, G. Abel, & M. Brusotti (Eds.), *Nietzsches Wissenschaftsphilosophie: Hintergründe, Wirkungen und Aktualität* (pp. 315–332). Berlin/Boston: De Gruyter.
- Schacht, R. (1999). Nietzsche: truth and knowledge. In B. Babich (Ed.), *Nietzsche, epistemology and philosophy of science. Nietzsche and the Sciences II* (pp. 25–38). Dordrecht/Boston/London: Kluwer.
- Schacht, R. (2011). Nietzsche's anti-scientific naturalism richard schacht. In H. Heit, G. Abel, & M. Brusotti (Eds.), *Nietzsches Wissenschaftsphilosophie: Hintergründe, Wirkungen und Aktualität* (pp. 161–186). Berlin/Boston: De Gruyter.
- Schiemann, G. (2014). Nietzsche und die Wahrheitsgewissheitsverluste im Abbruch der Moderne. In H. Heit & L. Heller (Eds.), *Handbuch Nietzsche und die Wissenschaften: Natur-, geistes- und sozialwissenschaftliche Kontexte* (pp. 46–75). Berlin/Boston: De Gruyter.
- Schlechta, K. (1969). Nachwort. *Friedrich Nietzsche: Werke III* (pp. 1433–1452). München: Hanser.
- Sloterdijk, P. (2001). *Nicht gerettet: Versuche nach Heidegger*. Frankfurt: Suhrkamp.
- Soderstrom, L. (2009). Nietzsche as a reader of Wilhelm Roux, or the physiology of history. *Symposium*, 13(2), 55–67.
- Solies, D. (2014). Nietzsche und die Lebenswissenschaften. In H. Heit & L. Heller (Eds.), *Handbuch Nietzsche und die Wissenschaften: Natur-, geistes- und sozialwissenschaftliche Kontexte* (pp. 107–118). Berlin/Boston: De Gruyter.
- Steinke, H. (2005). *Irritating experiments: Haller's concept and the european controversy on irritability and sensibility, 1750–90 (Clio Medica 75)*. New York: Rodopi.

- Treccani, I. (2014). Nietzsche und die Astronomie. In H. Heit & L. Heller (Eds.), *Handbuch Nietzsche und die Wissenschaften: Natur-, geistes- und sozialwissenschaftliche Kontexte* (pp. 155–169). Berlin/Boston: De Gruyter.
- van Tongeren, P. (1999). Nietzsche's symptomatology of skepticism. In B. Babich (Ed.), *Nietzsche, epistemology and philosophy of science. Nietzsche and the Sciences II* (pp. 61–71). Dordrecht/Boston/London: Kluwer.
- van Tongeren, P. (2011). Science and philosophy in Nietzsche's genealogy of morality. In H. Heit, G. Abel, & M. Brusotti (Eds.), *Nietzsches Wissenschaftsphilosophie: Hintergründe, Wirkungen und Aktualität* (pp. 73–87). Berlin/Boston: De Gruyter.
- Ward, J. (2011). The "little independent clockwork": Nietzsche on science and the will. In H. Heit, G. Abel, & M. Brusotti (Eds.), *Nietzsches Wissenschaftsphilosophie: Hintergründe, Wirkungen und Aktualität* (pp. 125–134). Berlin/Boston: De Gruyter.
- Welshon, R. (2009). Saying Yes to reality: Skepticism, antirealism, and perspectivism in Nietzsche's Epistemology. *Journal of Nietzsche Studies*, 37, 23–43.
- Zwart, H. (1997). What is an animal? A philosophical reflection on the possibility of a moral relationship with animals. *Environmental Values*, 6(4), 377–392.
- Zwart, H. (2000). Filologie of Fysiologie? Nietzsche en de Cultuurstrijd tussen Bildung en Wetenschap. In M. Van den Bossche & M. Weyembergh (Eds.), *Links Nietzscheanisme* (pp. 95–106). Damon: Budel.
- Zwart, H. (2008a). *Understanding nature. Case studies in comparative epistemology*. Dordrecht: Springer.
- Zwart, H. (2008b). Pea stories. Why was Mendel's Research Ignored in 1866 and Rediscovered in 1900? In *Understanding nature. Case studies in comparative epistemology*. Dordrecht: Springer. ISBN 978-1-4020-6492-0.
- Zwart, H. (2009). Biotechnology and naturalness in the genomics era: Plotting a timetable for the biotechnology debate. *Journal of Agricultural and Environmental Ethics*, 22, 505–529.
- Zwart, H. (2010). The Nobel Prize as a reward mechanism in the genomics era: Anonymous researchers, visible managers and the ethics of excellence. *Journal of Bioethical Inquiry*, 7, 299–312.
- Zwart, H. (2016a). The obliteration of life: Depersonalisation and disembodiment in the terabyte age. *New Genetics and Society*, 35(1), 69–89. <https://doi.org/10.1080/14636778.2016.1143770>.
- Zwart, H. (2016b). Psychoanalysis and bioethics: A Lacanian approach to bioethical discourse. *Medicine, Healthcare and Philosophy*, 19(4), 605–621. <https://doi.org/10.1007/s11019-016-9698-1>.
- Zwart, H. (2017a). *Tales of Research Misconduct: A Lacanian diagnostics of integrity challenges in science novels. Library of ethics and applied philosophy* 36. Dordrecht: Springer. ISBN 978-3-319-65554-3.
- Zwart, H. (2017b). The oblique perspective: Philosophical diagnostics of contemporary life sciences research. *Life Sciences, Society & Policy*, 13, 4. <https://doi.org/10.1186/s40504-017-0047-9>.
- Zwart, H. (2018). Scientific iconoclasm and active imagination: Synthetic cells as techno-scientific mandalas. *Life Sciences, Society and Policy (collection: Synthetic biology)*, 14, 10. 1–17.

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Hub Zwart** studied philosophy and psychology at Radboud University Nijmegen (1960), worked as a research associate at the Centre for Bioethics in Maastricht (1988–1992) and defended his thesis in 1993. In 2000 he became full Professor of Philosophy at the Faculty of Science RU Nijmegen and in 2018 he was appointed as Dean of Erasmus School of Philosophy (Erasmus University Rotterdam). He published 15 books (4 in English) and >100 academic papers. He is editor-in-chief of the Library for Ethics and Applied Philosophy (Springer) and of the journal Life Sciences, Society and Policy (Springer). In his research he develops a continental philosophical assessment of contemporary technoscience. Special attention is given to genres of the imagination (novels, plays, poetry) in research and education.