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Mathematical Anamneses

> If we awaited perfection, we would never move forward. It is everywhere like here: supposing the Greeks had waited for the complete demonstration of their axioms, for their reduction to identical, geometry would still to be done. Mathematics presupposes axiomatics, but not perfection; we can develop the consequences of the former, downstream [*en aval*], for example by inventing the differential calculus with a lot of pragmatism and little rigour, while simultaneously, going back upstream [*à l'amont*] of the axioms and definitions in order to logicize them. So is the method of Establishments: once this is agreed upon, this is beyond of dispute. Likewise, without awaiting the perfection of philosophy – in this regard "we are in a certain infancy of the world" [*nous sommes dans une certaine enfance du Monde*], we are at an antepythagorician stage – we have to work on its elements and to build a first alphabet of human thoughts, but we must also go to the other extremity of the positive and order the proliferation of written or spoken tongues: study Chinese, hieroglyph, cuneiform, the "Indo-European" languages, demonstrate their harmony. Advancing one enterprise cannot not have effect on the process of the other. By multiplying "samples" set beyond dispute, by pluralising the results of this molecular and regional method, we can hope, bit by bit, to cover unknown territories. Hence achievement [*l'achèvement*] and perfection are in the end understood as goals, as horizon, not as prior conditions.[1]

In more than one way, Michel Serres's philosophy can be said to evolve through processes of translation: one concept is overtaken by another, of which domain of reference overlaps with the former whilst leaving an irreducible remainder. Transiting between mathematics, philosophy and the history of science, Serres's concepts became increasingly 'interferential' as they moved between regional, disciplinary, and formal languages.[2] Paradigmatic of these translational processes are the *methodic* concepts (or rather *pairs* of concepts) by which Serres

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[1] Michel Serres, *Le Système de Leibniz et ses modèles mathématiques, Etoiles-Schémas-Points* (Paris, Presses Universitaires de France - PUF, [1968] 2007), 550-1. Otherwise indicated, all translations are mine.

[2] On the concept of 'interference' as a mode of transdisciplinarity, see Michel Serres, *Hermès II, l'interférence* (Paris: Editions de Minuit, 1972).

set out to explore the dual constitution of Leibniz's scientific method in *Le Système de Leibniz et ses modèles mathématiques* (1968). Pairs of opposites such as 'local vs. global', 'perspective vs. ichnography', 'applied vs. axiomatic', and later 'procedural vs. declarative', have continually structured Serres's philosophical investigations.

Initially, these conceptual pairs were meant to underline the novelty of Leibniz's mathematical method, a method which propelled Leibniz ahead of the Classical Age. Whereas Descartes's reasoning was grounded on a *tabula rasa*, requiring to understand all of A to posit B, Leibniz proceeded by method of 'Establishments' (*Etablissements*), establishing *hypotheses* on which he could always return. In his quest for truth and universality, Leibniz equipped himself with *networks* of conditionality while Descartes sought to ground knowledge in apodictic or declarative certainty. Excerpted from a section of Serres's doctoral dissertation evocatively titled 'The Universal Cycle', the above passage offers a good starting point to think about the possible projection of Leibniz's *ars inveniendi* into Serres's own philosophical method, starting from the *Hermès* series (1968-1980). Such a philosophy is capable of 'doing with little' (letters or elements, details or molecular samples) whilst keeping 'complete' totalities (languages, systems) as horizon. Completion and rigor are not the grounds but the receding and always *futural* limits of the investigation.[3] Following Leibniz, Serres's methodic endeavour is not prescriptive but instead seeks to penetrate the logic of invention.

More recently in his *Eloge de la philosophie en langue française* (1995), Serres reframed the notion of a local, perspectival, applied mathematics from the standpoint of new technologies. Whereas the *System of Leibniz* and his early 1960s philosophy reflected Serres's interest in cybernetics, the pair 'procedural vs. declarative' emerged from a renewed enthusiasm for computational technologies at the end of the first millennium. Procedural methods, he explains in *Eloge de la philosophie*, function through algorithms, i.e. through repetitive operative rules or

[3] Leibniz, Serres argued, devised a *double* method of universality: the first one starts from an *elemental* consistency (the monad, the singular), on which he reads the universal law, while the second starts from the *mathesis* (the monadology, the system) or abstract generality, from which he proposes to derive the particular. In Leibniz's system, these universalities form a *cycle*, meaning that these two methods are fundamentally co-conditional and cannot be dissociated.

mechanistic procedures. Mathematics, he reiterated, is equipped with a double universality: a universality that proceeds through abstraction and purification and a constructive mathematics oriented by the singular, technical and applied. The latter relies on the repetition of elementary procedures and applications that do not need to be 'mathematical' *stricto sensu*. This dual constitution of mathematics, paramount throughout Serres's early works, points to what Marcel Hénaff aptly characterized as 'a double history of reason'.[4] Indeed Serres consistently highlighted the importance of this other form of mathematical reasoning: a method that does not discriminate between mathematics and technique, mathematical 'purity' and technical inventiveness. This is not to say that Serres sought to abolish the distinction between purity and technicity. To the contrary, Serres pointed to a more profound sense of this distinction, which Serres developed through engaging with the philosophy of mathematics and the epistemology of science.

This chapter will tackle this crucial distinction from the vantage point of Serres's earliest philosophy of mathematics by looking at Serres's seminal 'Les anamnèses mathématiques' (1967) alongside other essays on the origin of geometry published across the *Hermès* volumes.[5] In these texts, Serres's critique of reason focuses on two foundational myths of mathematics: the 'origin of geometry' and the 'crisis of the foundations' of the turn of the Twentieth century. Working at the convergence of the philosophy of mathematics and the history of science, as well as within the intricacies of the French epistemological tradition, Serres examined the question of mathematical origins both from a transcendental and a historical point of view. After Bachelard, Serres was indeed trying to conceptualize an impure *apriori* against Kant's declaration that 'absolutely no concepts must enter into it that contain anything empirical, or that the *a priori*

[4] Marcel Hénaff, 'Of Stones, Angels and Humans' in Niran Abbas, *Mapping Michel Serres* (Ann Arbor: University of Michigan Press, 2005), 183.

[5] These texts are: 'Ce que Thalès a vu au pied des pyramides', first published *Hermès II, L'Interférence* (1972) and translated into English as 'Mathematics and Philosophy: What Thalès saw… ' in *Hermès: Literature, Science, Philosophy* (1982), 84-97 ; and 'Origine de la géométrie' 3, 4 and 5 in *Hermès V, Le passage du Nord-Ouest.* Only 'Origine de la géométrie 5' has been translated into English as 'The Origin of Geometry' in *Hermès: Literature, Science, Philosophy* (1982), 125-133.

cognition be entirely pure'.[6] But unlike Foucault and Bachelard, Serres's reflection developed primarily on the terrain of mathematics, and more specifically at the level of the *historicity of mathematics*. In this regard, I will show that it is crucial to include Jean Cavaillès as a third name among Serres's philosophical references. Examining the distinctiveness of Serres's epistemological critique, I will argue that the concept of *translation*, paramount throughout Serres's early works, was the operator, which enabled him to explore the dual constitution of mathematics as the essence of its historicity, between technicity and purity, or translation and foundation.

Autochthonous Epistemology

After Auguste Comte, French philosophy of science's main impulsion has been to move away from the epistemological naturalism that had previously dominated. Such an 'exterior epistemology' could only miss the movement of science itself.[7] This imperative remained one of Bachelard's fundamental legacies in defining the relationship between philosophy and the sciences. As Canguilhem wrote in 'What is a Scientific Ideology?,' this 'requires an installation in the content of scientific enunciations (*énoncés*) and this 'installation' can only be a practice.'[8] Through this problem, 1960s epistemologists of science were obliquely contemplating the idea of philosophy's disappearance: either 'redundant' in accompanying the workings of science, or 'logicist' but a-historical.[9] As a consequence, it was through a different treatment of *history* that philosophy could hope to find its way to the sciences. 'If epistemology is historical, the history of

[6] Immanuel Kant, *Critique of Pure Reason*, trans. Paul Guyer and Allen W. Wood (Cambridge and New York: Cambridge University Press, 1998), 134.

[7] On this question, see Michel Serres, 'Transdisciplinarity as Relative Exteriority', trans. Lucie Mercier, in *Theory, Culture and Society* 32 (5): 37-44.

[8] Georges, Canguilhem, 'Qu'est-ce qu'une idéologie scientifique?' in *Idéologie et rationalité dans l'histoire des sciences de la vie: nouvelles études d'histoire et de philosophie des sciences* (Paris: Vrin, 1977), 108; 'What is a Scientific Ideology', *Radical Philosophy* 29 (1981): 20.

[9] Michel Serres, 'La querelle des anciens et des modernes', in *Hermès I, La communication* (Paris, Editions de Minuit, 1968), note 1, 66.

science is necessarily epistemological.'[10] For Serres as for Canguilhem, locating epistemology within the historicity of science constituted a way of resolving the problem of the 'secondary' or 'derived' status of epistemology. Rather than articulating a 'discourse upon another discourse', an internal epistemology was to be sought *within the effective process* of mathematics. Every science was the host of an implicit theory as it unfolded in time.

'Les anamnèses mathématiques' (1967),[11] provides us with a condensed overview of Serres' approach to these questions. This lengthy article needs to be grasped in the context of the debates around the *history of truth*, which formed the immediate environment for Serres's writings at the time. Emerging simultaneously in the works of Canguilhem, Derrida and Foucault, among others, this debate consisted, broadly speaking, in the reproblematization of the status of science (and its truth) in relation to its outside, be it culture, ideology or history as its conditions of production or possibility.[12] The kernel of Serres's reflection is a problem that is formulated in 'The Mathematical Anamneses' as follows. Mathematics can be understood as a 'well-formed language'. This 'pure logos ' should be, as such, impervious to historicity (containing an *invariable* truth). At the same time, it seems that its truth can only be established 'by reference to the global system that contains it and makes it possible'.[13] In other words, how can mathematics be at once *autonomous* and *heteronomous*? The paradox dissolves, Serres claims, if we consider the history of mathematics as

[10] Georges Canguilhem, 'Introduction ' in Dominique Lecourt, *L'épistémologie historique de Gaston Bachelard* (Paris: Vrin, 2002), 9.

[11] Serres indicates that this text was written in 1966. It was initially published in 1967 in *Archives internationales d'histoire des sciences* 20, and then republished in 1968 in *Hermès* I, *La Communication* (78-112). Twenty-five years later it was trimmed to figure again as the opening chapter of *Les origines de la géométrie* (1993) under a new heading: 'Differences : Chaos in the History of Sciences' (15-35). I will base most of my analyses on the 1968 version of the text.

[12] According to Etienne Balibar, the expression 'history of truth' is at the crux of the debates around logics, epistemology and phenomenology that animated the French philosophical scene between the 1950s and the 1980s. For Balibar, this expression marks the specificity of the French 'moment' of the 1960s, conferring it 'a relative autonomy with respect to its international environment ' Etienne Balibar, 'The History of Truth: Alain Badiou in French Philosophy', in Peter Hallward (ed.) *Think Again: Alain Badiou and the Future of Philosophy* (London ; New York: Bloomsbury Academic, 2004), 23. The question is addressed at great length in his chapter 'Être dans le vrai?', in *Lieux et noms de la vérité* (La Tour d'Aigues: Editions de l'Aube, 1994), 163-209.

[13] Serres, 'Les anamnèses mathématiques', *Hermès I,* 78.

> […] *the (meta)morphoses of a logos referred to* itself - mathematics being the science of this auto-reference, and rigour, the science of this application.[14]

This enigmatic formula announces, in a nutshell, what I will gradually disentangle in this chapter. In order to unfold Serres's claim I will refer to other texts on mathematics published across the *Hermès* series. I will show that Serres' original contribution to the aforementioned epistemological debates is not so much to consider science or mathematics as a language, as to consider it as a permanent translation of itself and endow it with a singular form of historicity. Indeed, the reflexive process of mathematics upon itself does not lead to an infinite abyss of pure reflection, but is marked by the cultural and historical 'impurities' stemming from the irreducibly historical character of languages. I will show that, although mathematics remains the paramount example of a self-grounding discourse and an autochthonous language, it is also a fundamentally *impure* language. For Serres, 'mathematical historicity is nothing else than the history of an impurity, which means of a certain type of non-mathematicity'.[15] Grasping the specificity of mathematical historicity requires us to show how the latter is at once a self-grounding language and a historical one. This search for a historical definition of the mathematical *a priori* can therefore be held as constituting Serres' own strategy to historicize the transcendental.[16] Yet, historicizing here does not mean objectifying or naturalizing its process from without, but, importantly, adopting an inner perspective on mathematics. As I will unravel in detail, this inner perspective is none other than that provided by the process of translation itself. Indeed, Serres demonstrates that by translating itself in new languages, by translating its 'atoms of sense' into new idioms, mathematics unceasingly transforms its own grounds.

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[14] Ibid.

[15] Ibid., 92-3.

[16] Serres's early 1960s project of recasting the Kantian transcendental took various forms. Alongside his works on mathematics which attempted to *historicize* the transcendental, he also developed the concept of an '*objective* transcendental' (*transcendental objectif*). On this notion, which lies beyond the scope of the present chapter, see Michel Serres, *Hermès II, L'Interférence* (Paris : Les Editions de Minuit, 1972) and Anne Crahay's synthetic commentary: *Michel Serres: la mutation du cogito : genèse du transcendantal objectif* (Bruxelles, De Boeck Supérieur, 1988).

Mathematical Historicity

Serres's reflections on the self-grounding character of mathematics owe much to the philosophy of Jean Cavaillès. As Cavaillès, Serres considered that the philosophy of mathematics could not remain unchanged after the so-called 'crisis in the foundations' at the turn of the Twentieth century and the far-reaching questioning of the foundations of mathematical activity that this crisis had sparked off.[17] According to Cavaillès, this crisis had revealed that mathematics had to be considered as an autonomous becoming, a *sui generis* historicity.[18] For him, the crisis of mathematics opened by Gödel's incompleteness theorem[19] entailed the absence of any apodictic insurance to start with: 'one needs to entrust the canonical process, the indefinite iteration of its use. And thus the deductive sequence is essentially creative of the contents that it reaches.'[20] In his unfinished and posthumous *On Logics and Theory of Science*, Cavaillès proposed to grasp the demonstrative process, *i.e.* the essence of mathematical historicity, through two basic operations: paradigmation and thematization. *Paradigmation* designates the operations of abstraction and substitution by which a structure can be deduced from a given operation; it is fundamentally oriented towards its objects.[21] In opposition to the longitudinal character of paradigmation, *thematization* refers to a vertical movement, a reflexive reversal of thought towards the meaning of its operations.[22] These two perspectives on the 'motor effect of

[17] This debate was launched by Cantor, Frege, Russel and Whitehead, and pursued by Brouwer, Dedekind, Hilbert, Atkin, to name a few, from the late nineteenth century to the 1930s. For Serres, this event had not only proven determinant in the history of mathematical theory and subsequent findings, it also marked a point of rupture between 'classical' and 'modern' mathematics. On this topic, see: Serres, 'La querelle des anciens et des modernes', *Hermès I,* 74.

[18] Jean Cavaillès and Albert Lautman, 'La pensée mathématique', in *Oeuvres complètes de philosophie des sciences* (Paris: Hermann, 1994), 595-630.

[19] In a nutshell, Gödel had shown that no consistent theory containing the theory of integers could be complete or entirely proven within that theory.

[20] Jean Cavaillès, *Sur la logique et la théorie de la science*, (Paris: PUF, [1947] 1960), 73.

[21] See: Cavaillès and Lautman, 'La pensée mathématique', 602.

[22] Pierre Cassou-Noguès, *De l'expérience mathématique, Essai sur la philosophie des sciences de J. Cavaillès* (Paris: Vrin, 2001), 272; Florian Reverchon 'Mathématique et expérience: ontologie et humanité des mathématiques' in *Interphase* no. 1 (2014): 21-2.

abstraction'[23] were crucial in establishing the 'singular becoming of mathematics'[24] as autonomous, necessary and unpredictable at the same time. In Cavaillès's own words, the structure of science 'displays, in its movement, the principle of its necessity. Structure speaks about itself.'[25]

From his earliest writings onwards, Serres generalized Cavaillès' proposition; he made of the problem of the fundaments the main vector of mathematical transformation, putting forward the *crisis*[26] as historical principle against the presumptuousness of epistemology.[27] As he wrote in 'The Quarrel of the Ancients and the Moderns' (1963), modern mathematics has the singular intention to 'take itself as object; and, in particular, as object of its own discourse.'[28] 'At each moment of great systematic reconstruction,' he observes, 'mathematicians become the epistemologists of their own knowledge. This transformation is a mutation effectuated from the inside.'[29] The crucial point for Serres is that as much as this reflexive discourse *closes off* mathematics to the external discourse of traditional epistemology, mathematical language also *opens* itself to an always greater number of objects because it is inhabited by a movement of purification, or increased abstraction. Mathematics is not pure, it moves towards purity. Mathematical theory is, Serres argues, 'internally open, and externally closed'[30]. 'The (paradoxical) result of this closure to any other domain of knowledge is that the organon, the

[23] Hourya Benis-Sinaceur, 'Structure et concept dans l'épistémologie mathématique de Jean Cavaillès ', in *Revue d'histoire des sciences* 40, no.1, (1987): 25.

[24] Cavaillès and Lautman, 'La pensée mathématique', 594.

[25] Cavaillès, *Sur la logique,* 24. Cavaillès' reflection on the *structuration* of mathematical 'thought' (or 'experience') emerged from the same intellectual space as Bourbaki's 'algebraic structures', in the formalism of the Göttingen school (Hilbert, Artin, Noether), and is thus directly related to Serres' views. See: Hourya Benis-Sinaceur, 'Structure et concept dans l'épistémologie mathématique de Jean Cavaillès ', *Revue d'histoire des sciences* 40, no. 1 (1987): 5-30.

[26] As a matter of fact, the crisis had been of continuous relevance since the early Twentieth century, constituting, as José Ferreiros argues, 'a long and global process, undistinguishable from the rise of modern mathematics and the philosophical and methodological issues it created'. (*The Princeton Companion to Mathematics*, Gowers et al. (eds), (Princeton: Princeton University Press, 2010, 142.)) In 1960, for Serres, the crisis was still open. Serres interpreted it as a self-reflection of classical mathematics, which had brought about new strata of language. 'La querelle des Anciens et des Modernes', *Hermès I,* 74.

[27] 'Is there not', Serres writes, 'a lot of presumptuousness in arrogating the right to talk [*discourir*] about a rigorous language without first settling the language of this discourse?' (Ibid., 62.)

[28] Ibid., 59.

[29] Ibid., 68.

[30] Ibid., 72.

language thus purified, becomes universal. The movement of closure is universalising.'[31] In the precise way of a Leibnizian Monad, 'the most *independent* language is the language of languages. The least windows, the most universal reflection.'[32]

> In the mirrored avenue spoken of by Lautréamont, a route is to be followed, continuous or fragmented, of light rays. This open avenue is the very history of mathematics, the *history of a language* in which words strictly respond to each other, a language infinitely translated into new but homologous languages, the history of auto-referred systems, therefore closed, referring to other systems, therefore open, but referring to other systems similarly mathematical, therefore closed […] *The history of forms* making sense within a system is thus involuted, but sometimes, and seemingly all of a sudden, taking another sense than the autochthonous, overtaking their interior auto-reference and therefore evolving outside the system, like a pathological outgrowth, towards a new internal systematic reference, like a lost ray looking for a mirror […] *The history of truths* is always in quest of an enclosed universe which locks them upon themselves, which gives them an existence and possibility, until the rigour requirement makes the interior application intolerable, and shatters the lock for a larger and better enclosed reference […][33]

For the early Serres, mathematics is not a principle of subsumption, but one of expression, circulation and speed. Evolving between self-referentiality and invention, mathematics unceasingly needs to expand its domain of reference and thus to translate its own grounds into new languages. Serres's reflections thus re-actualizes the Leibnizian problematic of the *mathesis universalis*, at once universal language and foundation of knowledge, from the standpoint of the history of mathematics: 'The tower of Babel, indefinitely made anew, reconstructs itself as soon as new promotions cannot use the same language with one another, nor with the previous system.'[34] In this sense, mathematics does not so much constitute a language as it incarnates a

[31] Ibid., 72-3.
[32] Ibid., 73.
[33] Ibid., 79.
[34] Serres, 'Les anamnèses mathématiques', *Hermès I*, 97; *Les origines de la géométrie* (Paris: Flammarion, 1993), 25.

continuous *search* for a language; Lacking definitive foundations, mathematics remains in a permanent state of crisis.[35]

In other words, Serres considers that the problems of classical epistemology have been *transported* into 'scientific technique', rendering the 'epistemology of science' redundant.[36] Such an internal meta-language does not limit itself to describe the course of mathematical transformations but it also has an impact on the latter: 'far from stabilising or naturalising mathematics, [internal epistemology] reconstitutes it, vivifies it, restructures it.'[37] In other words, this reflexive language is fundamentally productive, reactivating its truths into new settings. Moreover Serres takes up the mutual imbrications between mathematics and this autochthonous epistemological discourse as an occasion to explore the idea of a *philosophy of the history of science*, taking a step further than Cavaillès who had mostly remained at the level of 'mathematical experience'. Although systematic, Serres's 'philosophy of history' encompasses multiple logics of temporalization. On the grounds of his previous reflections on systematicity in Leibniz, Serres indeed suggests we think the historicity of science as a complex network of mathematical idealities. Serres's 'philosophy of history of science', although system-oriented, can only exist in the plural and by dividing itself into a multiplicity of *models* of historicity.[38]

In this context, Serres also lays the groundwork of a complex analysis of the history of science as a 'history of truth'. Insofar as the history of science can be characterized as a zone of contact (*lieu de contact*) between ideality and historicity, Serres argues in 'The Mathematical Anamneses', it is situated at the clashing point between two normative systems.[39] This implies the fundamental *indetermination* of the history of sciences, 'either *I know the position of the concept and I ignore*

[35] Serres, 'Les anamnèses mathématiques', *Hermès I*, 106.
[36] Serres, 'La querelle des Anciens et des Modernes', *Hermès I*, 55.
[37] Ibid., 64.
[38] Serres, 'Les anamnèses mathématiques', *Hermès I,* 85-95. Addressing Serres's analysis of the historicity of science in greater depth would require going back to his doctoral thesis. In *The System of Leibniz*, Serres had suggested we interpret Leibniz's conception of historical progress through a variety of mathematical models. According to him, Leibniz's achievement regarding the question of history was that he had not proposed *a* philosophy of history but had instead described a 'schematic dictionary, a formal inventory, drawing a space of choices on which he draws the graph of the history of possible histories.' Serres, *Le Système de Leibniz*, 284.
[39] Serres, 'Les anamnèses mathématiques', *Hermès I*, 85.

its speed (*vitesse*), […] *or I know its speed and I ignore its position*.'[40] Throughout his early works, Serres repeatedly thematized this indetermination through the figures of the 'historian', the 'scientist' and the 'epistemologist'.[41] Whilst the historian, in the manner of a documentarist, 'blindly gathers exhaustive details on a question' and so accesses the *unconscious* of science, but not its *truth*, the scientist inventor consciously intends this truth without access to its unconscious, or to the complete 'trajectory' of this truth. The epistemologist, perceived as the mediating figure between these two, needs both to 'know' and to 'circulate'[42]. Any ideality possesses three historical meanings (*sens*): 'its sense of birth, *i.e.* sedimented, naturalized; the whole of its senses at each reactivation […]'; as well as its recurrent sense for the retroactive restructuration of the whole (that is its scientific truth).[43] The history of science cannot be defined as continuous tradition anymore, but as a 'discontinuous, cut up weft (*trame*)'[44]. Therefore, to picture the history of science as the continuous communication of a tradition is fundamentally partial; 'it is a history that we try to make connected (*connexe*) and continuous by filling its breaks, while the scientist-inventor chops it and makes it discontinuous.'[45]

Whereas Cavaillès considered that each new moment of demonstration constituted a *dialectical* moment of mathematical experience, Serres considers that each new event of mathematical history constitutes a new *translation* of mathematics. Taking a more formalist and structural route than Cavaillès, Serres arguably moved one plane 'upwards', from experience to language (*langue*), distancing himself further from any reference to subjectivity. For Serres the self-grounding character of science is entirely contained in the structures and history of its language(s). Hence the critical importance of the concept of 'translation', which encapsulates at

[40] Ibid., 84.
[41] This way of reasoning is a clear influence from Bachelard, who writes, in *The Formation of the Scientific Mind*: 'It is therefore this striving towards rationality and towards construction that must engage the attention of epistemologists. We can see here what distinguishes the epistemologist's calling from that of the historian of science. Historians of science have to take ideas as facts. Epistemologists have to take facts as ideas and place them within a system of thought. A fact that a whole era has misunderstood remains a fact in historians' eyes. For epistemologists however, it is an obstacle, a counter-thought.' Gaston Bachelard, *The Formation of the Scientific Mind* (Manchester: Clinamen, 2002), 27.
[42] Serres, 'L'interférence théorique: tabulation et complexité, *Hermès II*, 40.
[43] Serres, 'Les anamnèses mathématiques', *Hermès I*, 84.
[44] Ibid.
[45] Ibid., 87.

once a series of operations of transformations per substitution and an act of reflexive, transversal thematisation, in short a '(meta)morphose'.

Purity, Technicity

Beyond mathematics, it is science itself that can be rethought through this autochthonous production of temporality. Every translation *reactivates* scientific truth in a new setting. The Platonic notion of anamnesis proves pivotal. While in Plato mathematical idealities' are referred to as the necessary return to their true origin 'before the cycle of incarnations',[46] Serres couples anamnesis with the Bachelardian notion of 'covering-up' (*recouvrement*), which functions, in this occasion, as its dialectical counterpart. Whilst for Bachelard it was philosophy that displaced and covered-up scientific problems,[47] for Serres the movement of *recouvrement* is a constitutive part of the historicity of science. For the latter, any reactivation leads to a certain *forgetting*, any truth can become an obstacle, and the existence of new forms only brings about new histories of science *at the price of others*, transforming the latter into 'modes of nescience.'[48] Importantly, the latter is never an absolute situation, for past scientific truths remain valid. 'Take the field of dead histories: Greek geometry, classical analysis [...]. Dead but not false: what is this death of the true which never turns to error?'[49] This, in turn, illuminates the paradoxical situation of the history of mathematical truth announced by Serres at the beginning. For Serres, truth's 'name' can only be established through a broader set of referentials, ideology, cultural formations or language. But whilst the concept or mode of being of truth (*i.e.* the philosophy of mathematics) varies, the 'automatic essence of the true' (*l'essence automatique du vrai*) remains invariant through time: 'the true remains invariant through diachronic transformations, whilst the *concept of truth* changes.'[50]

[46] Jean-Michel Salanskis, *Philosophie des mathématiques* (Paris: Vrin, 2008), 145.
[47] Dominique Lecourt, *L'épistémologie historique de Gaston Bachelard*, (Paris: Vrin, 2002), 12.
[48] Serres, 'Les anamnèses mathématiques', *Hermès I,* 91.
[49] Ibid., 110.
[50] Ibid., 110.

More importantly, anamnesis or reactivation is defined as a translational undertaking. Mathematical invention is nothing other than a 'successful application of a region upon others, or even, an application of the system on itself.' Rather than accumulating the givens of its tradition, mathematics undertakes its heritage by filtering it, by always moving towards more encompassing syntheses and greater formal purity. The history of mathematics is, as such, the history of the theory of theory, whereby 'the science of science substitutes itself to science itself'.[51] The original movement of science 'defines a system of translations. Each synchronic cut possesses its conditions of translatability.'[52] The purifying process of mathematics is such that, we can always translate an anterior language into a posterior one, but the inverse is not true. Whilst Euclydian space can be translated into the language of topology, the reverse does not hold: 'the intersection between two repertories can be empty.'[53] The history of mathematical systems can hence be grasped as 'a tran-slation, resumed in every instant, history of discovering and re-covering (*découvertes et recouvrements*).'[54] Yet, and this is key, 'the translating correspondence fails as soon as it succeeds', there is no *perfect application*.[55] There is always a residual impurity that is later taken up and pursued further. This *unthought* of mathematical history corresponds to what has not been translated into the new language, but may come back, centuries later, once rendered intelligible through a new language. This ever-changing zone is the residual, which, produced by the passage through different translations, is not entirely captured in the new language or the new form, yet reachable from another language or another point of departure. In other words, if every translation entails a certain *recouvrement*, translation is the continuous fabrication of the unconscious of science. Serres conceives of these mathematical 'untranslatables' as the dynamic core (*moteur*) of its historicity: 'the origin of

[51] Ibid., 104.
[52] Ibid., 105.
[53] Ibid., 105.
[54] Ibid., 106.
[55] Ibid., 107.

history is starting anew at each translation into a new language.'[56] This clarifies our initial proposition, following which the history of mathematics designates the transformations of a language that is at once *self-referential* and *applied*: although mathematics is (we may say 'syntactically') a truly self-referential language, it is nevertheless ('semantically') fundamentally non transparent to itself. Mathematical truth only manifests itself historically through idioms that function as its successive materializations and the inherent imperfection of these languages constitutes the dynamic core of mathematical historicity.

A further consequence of this is that mathematical 'purity' is a fundamentally *relative* notion. The movement of mathematics towards a more and more refined purity and thus towards greater 'applicability' always retrospectively reflects the anterior stage as 'more technical.'[57] Therefore, by moving towards rigour and universality, mathematics also *discovers* its other origins: singular, applied, technical.[58] This discovery can only be made from within the process of mathematics. Indeed, 'a cultural formation is only accessible as pre-mathematical within and through the autochthonous process of mathematics,'[59] and never externally to it. In this sense, mathematics constitutes, according to Serres, an 'archaeological' form of research: by evolving towards purity, mathematics deepens its 'empirical' ground, its practical 'unconscious.'[60] The temporality of mathematics is fundamental dual, oriented at the same time towards its *telos* and towards its beginnings. In other terms there is no legitimate and illegitimate 'origin' of mathematical truth as each translational invention can be conceived as one; 'any origin is the origin as such'[61]. Furthermore, 'these two limits, these two 'origins' (pure

[56] Ibid., 108.
[57] Serres, 'L'interférence théorique: tabulation et complexité', *Hermès II, L'interférence* (Paris: Les Editions de Minuit, 1972), 51.
[58] Ibid., 52.
[59] Serres, 'Les anamnèses mathématiques', *Hermès I*, 102.
[60] There are two modes of archaeology: intrinsic and extrinsic. Intrinsic archeology is 'the movement mathematic as such, which ceaselessly reactivates its origins and deepens its foundations, by iteration of its internal recurrence, unravelling primitive idealities that were not mathematical and become so by this move.' As such, it is both recurrent and teleological. Extrinsic archeology, on another hand, consists in reading the prehistory of mathematics' *abandoned concepts*, and with these fossils to 'reconstitute the lost genesis of a lost ideality.' Unlike the first, this movement is only regressive: 'the progressive path of effectivity is forbidden and crossed [...] as the ideality it deals with is no longer mathematical.' (Ibid., 102)
[61] Ibid., 99.

vs. empirical) *can only exist by means of one another*, the first being arbitrarily as technical, the second as pure as one wants.'[62] From this standpoint, the 'miracle' of geometry's origin can only appear scandalous: what is miraculous in it is not purity, but the arbitrariness of this act, which 'designates as pure a mixed and complex ore.'[63]

Origins of Geometry

Like Husserl before him, Serres's reflections on the 'origin of geometry' extend largely beyond mathematics, providing an occasion to reflect on the origin of science and the birth of philosophy. On the one hand, the origination of mathematical idealities is held as a paradigmatic case for the understanding of ideal forms in general – their genesis, historicity and mode of being. On the other hand, the hypothetical threshold constituted by this 'discovery', marking a 'before' and 'after' which is at once historical and theoretical,[64] constitutes a vantage point on historicity as such. Such association was clearly set out by the late Husserl in 'The Crisis of European Humanity and Philosophy' (1935). At the beginning of the 1960s, Derrida, who was in the same promotion as Serres at the *Ecole Normale Supérieure*, had published his seminal commentary-introduction to Husserl's short essay, 'The Origin of Geometry'. This work, for which Derrida won the *Cavaillès prize* in 1961, contributed to the revival of this classical debate under radically new auspices. Serres' writings on the origin of geometry, which punctuate his entire early period of writings,[65] should be read in this double connexion, as a critical response to Husserl, and in parallel to Derrida's commentary.

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[62] Serres, 'L'interférence théorique: tabulation et complexité', *Hermès II*, 52. Emphasis mine.

[63] Serres, 'Les anamnèses mathématiques', *Hermès I*, 92.

[64] As Derrida remarks in his commentary of Husserl's 'Origin of Geometry ', the problem of the origin of idealities resides in the ambiguous character of this 'before ' and 'after. ' In this question, the genetic perspective and the consequential perspective are indeed interlaced in a singular way. See: Jacques Derrida, 'Introduction ', in Edmund Husserl, *L'Origine de la géométrie*, 3rd edition (Paris, Presses Universitaires de France, 1999), 55; Jacques Derrida, *Edmund Husserl's 'Origin of Geometry': An Introduction*, trans. by John P. Leavey Jr (Lincoln: University of Nebraska Press, 1989), 65.

[65] The presence of this thematic both at the beginning (*Hermès I*) and at the end of the series (*Hermès V*) indicates, I believe, its crucial importance. When coming back to it in *The Origins of Geometry* (1993), Serres stressed that he had been thinking and writing about the origins of geometry since 1958.

As Derrida argues, Husserl is not interested in the *factice* historical event standing for geometry's origin; his intent is historical-transcendental as he tries to overcome the Kantian separation between innate ideal objects and empirical history, to mediate between the interior assumption of mathematical truths (or sheer Platonic anamnesis) and its purely extrinsic conditions of apparition.[66] Husserl aims at explaining how geometry, in its historical development, constantly reactivates its origins and constitutes an original form of historicity, which serves as a paradigmatic case not only for its historicity but also for idealities in general. Husserl's essay is focused on the elaboration of an original historicity of science detached from the empirical history-of-facts, which nevertheless has the latter as its condition.[67] This original historicity supposes the 'always reproducible, inaugural signification' (*Erstmaligkeit*) of the first concrete and lived *act* of geometrical idealisation or 'proto-foundation', which each of its subsequent reactivations re-opens. The continuity of tradition that Husserl describes is not ensured by its chronological continuity but by the unity of its becoming: 'it is a *history* only because it is *one* history.'[68] This unity depends both on the identity of the intentional act of idealisation and on the identity of the language in which it is expressed. The possibility of such universal language (or language in general) is the reciprocal condition of what Husserl calls 'co-humanity' or the awareness of constituting *one* community, of belonging to the same world.[69]

For Serres, the origin of geometry is an origin, not in the sense of an absolute, or sovereign beginning, but *in so far as it opens up the process of translation,* which science would thereafter not cease to be.[70] Reactivation is not understood as a repetition of the intentional act of a single, 'proto-founding' and primary idealisation, but becomes, in Cavaillès's sense, self-grounding. Through the concept of translation, Serres proposes to enter the effective process of science (*le procès effectif de la science*) without recourse to any notion of consciousness, grounding its

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[66] Jacques Derrida, 'Introduction ', in Edmund Husserl, *L'Origine de la géométrie*, 23-4.
[67] Ibid., 56 & 175.
[68] Ibid., 38.
[69] Ibid., 74.
[70] Serres, 'Les anamnèses mathématiques', *Hermès I,* 107.

'generating necessity' in its 'material progress.'[71] Whereas Husserl considered the origin of geometry as unveiling of its rational *telos*, Serres dislocates this unilinearity by giving a multiple account of the origin.

> [T]o raise the question of the Greek beginning of geometry is precisely asking how we moved from one language to another, from one type of writing to another, from the so-called natural language and its alphabetical notation to the rigorous and systematic language of numbers, measures, axioms and reasoning *in forma*. But our documents can only *display* these two languages, on the one hand, narratives or legends and on another, demonstrations or figures. […] And so we are stationed, facing these two parallels that never touch one another. This origin is running ahead, inaccessible, un-seizable. The problem is set out.[72]

The putative origin of geometry can be figured at the (impossible) convergence of two parallel lines: that of the geometers and arithmeticians and that of legends or histories. Between these formalisms and these narratives, between 'scientists' and 'historians', the 'epistemologist' can only operate punctual translations. In spite of the disparity of arguments invoked by Serres in his different narratives of the origin of geometry, each situation displays a certain relation (*rapport*), a certain passage from one realm of forms to another, *hence a translational situation*. As a result, univocity is not the '*a priori* and *telos*' of equivocity anymore,[73] but the reverse is true: equivocity makes up the surroundings, and the uneliminable milieu of univocity. Translations are passages conducting from univocity to equivocity, to univocity and so on, in an unending process. Rather than 'communicating' through their common origin (that is also their *original*), mathematical idealities evolve by restlessly transporting themselves: between spaces, graphs, channels. As Serres would later sum up, 'the history of mathematical sciences resolves the question of origin without exhausting it. It tirelessly responds to it while delivering itself from it.'[74]

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[71] Cavaillès, *Sur la logique,* 78.

[72] Michel Serres, 'Origine de la géométrie, 5', in *Hermès V, Le passage du Nord-Ouest* (Paris: Editions de Minuit, 1980), 185. Emphasis mine.

[73] See: Derrida, *Edmund Husserl's 'Origin of Geometry'*, 107.

[74] Serres, *Les Origines de la géométrie*, 214.

Symmetry

In 'Origine de la géométrie 4', Serres conceives the translational origin of geometry as a relation between two types of writing: Egyptian and Greek. Geometry does not emerge in the mind of the first geometer, 'be it named Thalès or as one wants', but in the field of possibilities produced by the translation between two inscriptions. Whilst hieroglyphs are figural and diagrammatic, Greek alphabet is literal and algebraic.[75] Serres proposes we view the origin of geometry as the result of an encounter between the Egyptian skill of representation and cartography and the convention and formalism of the Greeks.[76] Geometry thus emerges from the 'short-circuit' between forms and formalism, between the hieroglyphic signaletic of words-things and the Greek metalanguage of words-signs. Here, under the heading of the origin of geometry, Serres is also examining the origin of idealities as *signs*, at the convergence of image and discourse.[77] He underscores the language of drawings and topology as the prior conditions of abstraction and rereads the foundational claims of Euclidian geometry through this lens. In Serres's philosophy, mathematical idealities are historical condensations or sedimentations, which are to be unfolded into series of heterogeneous procedures.

As Serres argues in 'What Thalès saw…', first published as part of *Hermès II, L'Interférence* (1969) and greatly extended in *The Origins of Geometry*, the invention of geometry can also be grasped as a series of 'ruses' or translations enabling the measurement of the immeasurable. Serres reinterprets the famous legend of Thalès at the pyramids narrated by Plutarch and Diogenes Laërtius as the making accessible of the inaccessible through the discovery of the notion of a group of similitudes.[78] According to this legend, Thalès indeed used the sun as an invariant in the determination of a series of relations, which could only be captured through the creation of a reduced model. Thalès most important discovery thus

[75] Alessandro Delcò, *Morphologies. A Partir Du Premier Serres*, (Paris : Editions Kimé, 1998), 21.
[76] Serres, 'Origine de la géométrie, 4', *Hermès V,* 179.
[77] Ibid.,182.
[78] Ibid., 187

appears to be the construction of a summary, a reduction capable of rendering the immeasurable - the precise height of the pyramids - tangible. From this perspective, the origin of geometry is only the application of a certain relation (*rapport*) between two forms. Knowledge comes down to a technique of replication. Such an 'archaic' geometry, Serres writes, 'inserts itself in the open chain of those utterances and designations, but it does not provide the key of the number, it does not excavate the secret articulation of the knowledge and practice in which the core of a possible origin resides [...] it measures the problem, takes it dimensions, poses it, weighs it, makes it visible, relates it but does not resolve it.'[79]

Throughout Serres's series of early texts on the origin of geometry, mathematicity is not located *in* pure forms, but in these applications. The rigour of mathematics is none other than an infinite development from translation to translation. Losing its character of absolute and thereby originary determination, purity becomes the result of a previous application, the making explicit of an implicit knowledge.[80] Scientificity is thus always preceded by rigour: applications and translations constitute the irreducible technicity of scientific discourse. Furthermore, Serres does not only relativize the origin by pluralising it, but also by *symmetrising* it, thinking the origin as a circulating reference.[81] By thinking technicity and purity as the two *limits* of science, the 'origin' becomes a liminal passage, which can be read either from the point of view of abstraction and formalisation (towards purity) or from the point of view of archaeology

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79 Serres, Les Origines de la géométrie, 207; 'Ce que Thalès a vu au pied des pyramides', *Hermès II,* 172; Mathematics & Philosophy: What Thalès Saw… ', 91. The image of the rosetta stone provides Serres with another iteration of this idea (already fully formulated in his doctoral thesis), according to which the real problematic object is not the full determination of the languages (*langues*) at stake, but only the set of relations by which two languages succeed in corresponding to one another: 'Here, no language is unknown or undecipherable, no face of the stone poses problem, what is at stake here is the common edge of two faces, their common border, what is at stake is the stone itself.' (Ibid., 189.)

80 'What is the status of the knowledge implied by a certain technique? A technique is always an application that envelops a theory. The entire question - in this case the question of origin - boils down to an interrogation of the mode or the modality of that enveloping process. If mathematics arose one day from certain techniques it was surely by making explicit this implicit knowledge.' Serres, What Thalès Saw… ', 89.

81 This idea, which would be later exploited by Latour in his study of the successive translations by which scientific facts are produced, was also at stake in Claude Lévi-Strauss's *Mythologiques* (1964-1971). In the latter, he developed a method based on 'systems of transformations', relying on specific myths as 'circulating references'. On the latter notion, see: Bruno Latour, 'Circulating Reference, Sampling the Soil in Boa Vista', *Pandora's Hope: Essays on the Reality of Science Studies*, (Cambridge, Mass: Harvard University Press, 1999) 24-79 and on Lévi-Strauss's method: Gildas Salmon, *Les structures de l'esprit, Lévi-Strauss et les mythes* (Paris: Presses Universitaires de France - PUF, 2013).

(towards technicity). He thereby proposed a strongly anti-phenomenological version, not only of the history of science, but also of the birth of philosophy, whereby the hermeneutical conception of the origin as *question* (which, as an address, calls for a question in return or *Rückfrage*)[82] is overturned by a translational model. The question-response paradigm is substituted by a differential one, where movement or change arises from the necessity to respond to a crisis or a contact between languages. Philosophy and science would only be born from a variation. Hence, to the phenomenological or hermeneutical account of a *tradition of truth*, Serres opposes a translational reflection on the temporally complex, multilinear *history of truth*.

As Serres would put it again in *The Origins of Geometry* (1993), '[…] I do not communicate with the origin through the traditional historical channel, but through the effort of invention and foundation of mathematics itself. My regression does not follow the path of the indefinite ruling out of tradition, but through the vertical path of the mathematical *ars inveniendi*: It is through the latter that I reinterpret the historical tradition.'[83] Claiming an internal point of view on mathematical foundations, Serres drew a series of successive translational *tableaux*, in which scientific invention is equated to a liminal passage between languages. Between auto-reference and application, autochthony and heteronomy, Serres's philosophy of the history of science is both reflexive and blind to its own processes, leaving behind it a mysterious, untranslatable residual. By reading his reflections on the crisis of foundations and his texts on the origins of geometry alongside one another, I have underscored the crucial importance of translation in drawing a path between logicist and phenomenological approaches to the philosophy of mathematics, that is, as a continued reflection on the space left vacant by Cavaillès in his testamentary work *On Logic and the Theory of Science*. Going back to 'The Mathematical Anamneses' illuminates Serres's complex references to the philosophical debates of the 1960s, which disappeared in his successive 'anamneses' of the seminal essay.

[82] Jacques Derrida, *Edmund Husserl's 'Origin of Geometry'*, 12.

[83] 'Ma régression ne suit pas le chemin de la tradition, indéfiniment hors circuit, mais le chemin vertical de l'approfondissement mathématique: c'est à partir de là que je réinterprète la tradition.' Serres, *Les Origines de la géométrie* (Paris: Flammarion, 1993), p. 32; This passage was already in 'Les anamnèses mathématiques', H1, pp. 105-6. This 'ruling out' should be understood through his notion of 'external archaeology', cf *infra*, note 60, **[Enter page number]**

Today, alongside with Bourbaki, Thalès or Euclid, they might guide us back into the warps of his singular thought.

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