

Malebolge

On the High Open Sea Computational Empiricism and the Naturalization of Law

Nicola Lettieri*

*But I put forth on the high open sea
With one sole ship, and that small company
By which I never had deserted been.*
Ulysses in Dante Alighieri's 'Divine Comedy',
Inferno XXVI, trans. by H.W. Longfellow

*At first, I was deeply alarmed.
I had the feeling that,
beneath the surface of atomic phenomena,
I was looking at a more internal level
of mysterious beauty.*
W. Heisenberg, *Physics and beyond*
(London: Allen & Unwin, 1971), 129

Abstract

The paper projects into the legal universe a topic, the overcoming of the divisions between natural and social sciences, long central in philosophical debate. Fed by a longstanding research trajectory intersecting law, complexity theory, and computational social sciences, it advocates for a vision where law is conceptualized and studied in empirical terms as a natural phenomenon, a part of nature's world complexity in all its relations with the many levels of reality – from individual cognitive mechanisms to social macro dynamics – playing a role in its emergence and evolution. Cornerstone of the proposal is the ability of computational heuristics and methods to foster new ways to empirically understand reality; what Paul Humphreys, the philosopher of science, terms 'computational empiricism'. Laden with profound epistemological and methodological implications, this approach lays the groundwork for a research agenda convincingly non-disciplinary, open to radical questions and, to a large extent, yet to be built.

* Nicola Lettieri is researcher at the National Institute for Public Policy Analysis (Rome), associate researcher at the Institute of Cognitive Sciences and Technologies of the Italian National Research Council and adjunct professor of Legal informatics at the University of Sannio (Benevento). This paper represents an ideal continuation of a reflection begun long ago and developed within several papers. The ideas contained in these pages echo insights I first articulated in 2014 in the Research Topic call 'Law as a Natural Phenomenon: The Empirical Investigation of the Legal Universe between Complexity, Biology, and Computation' hosted by the journals *Frontiers in Interdisciplinary Physics*, *Frontiers in Evolutionary Sociology*, and *Frontiers in Social and Evolutionary Neuroscience* (<http://tinyurl.com/4ydx4rck>) last visited 10 February 2024). The author is truly grateful to Ilaria Pica for the precious and insightful comments given during the draft of this paper.

I. On the High Open Sea

I will not mince words. I think that anyone who agrees to write for a section named ‘Malebolge’ must be resolute like Dante’s Ulysses: fully committed to the ‘mad flight’, ready to ‘put forth on the high open sea’ without hesitation, made brave by the burning desire to open new frontiers.

This article resonates with such a spirit. In the following, I will provide some statements that are free from the fear of radical or unorthodox considerations, reflections born venturing far beyond the shores of traditional legal research. To this purpose, I will repeatedly and explicitly evoke a researcher who, to remain in a Dantean universe, embodied for me the figure of Virgil, a guide and source of inspiration. I refer to Domenico Parisi, philosopher of science, psychologist and cognitive scientist, a pioneer in fields ranging from psycholinguistics, to artificial life, artificial intelligence and evolutionary robotics, who has also devoted much of his thinking to the future of social sciences and their computational and non-disciplinary development.

Inspirer, quite literally, of generations of researchers from any field, Parisi has played a decisive role in the evolution of my research path and in convincing me of the need to look at the world of law ‘from the outside’, beyond disciplinary boundaries, in search of new ways to interpret and, therefore, understand reality.

I have always admired and shared this attitude for a number of reasons, but above all for the scientific results it leads to. Upon closer inspection, the story of the progress of science, is the story of the ability of human beings to move away from consolidated visions and conceptual structures to build deeper forms of understanding the world. If, for example, Boltzmann had not dared to search *out* from physics¹ solutions to interpret the behavior of systems composed of billions of particles, statistical mechanics would not have seen the light.

Fed by an experimental research path at the boundaries between law, complexity theory, and computational social science, this contribution tries to bring the ‘*ethos* of the external observer’² into the legal context through a reflection on the future

¹ We refer here to social statistics and Quetelet’s probability theory. On this point, see T. M. Porter, ‘From Quetelet to Maxwell: Social statistics and the origins of statistical physics’, in R. Cohen ed, *The Natural Sciences and the Social Sciences* (Dordrecht: Springer, 1994), 345-362.

² Such an approach led me to engage with the most diverse research areas from computational legal studies to cognitive science via complexity theory. Among the works done in between these fields: N. Lettieri, ‘Fuori da uno splendido isolamento. Le scienze cognitive negli orizzonti della scienza giuridica’ *Sistemi Intelligenti*, 22, 323-336 (2010); Id and D. Parisi, ‘Neminem laedere. An evolutionary agent-based model of the interplay between punishment and damaging behaviours’ 21(4) *Artificial Intelligence and Law*, 425-453 (2013); N. Lettieri, *Ius in silico. Simulazione, computazione, diritto* (Napoli: Edizioni Scientifiche Italiane, 2013); Id, ‘Computational Social Science, the Evolution of Policy Design and Rule Making in Smart Societies’ 8(2) *Future Internet*, 19 (2016); Id et al, ‘The legal macroscope: Experimenting with visual legal analytics’ 16(4) *Information Visualization*, 332-345 (2017); Ead, ‘Platform economy and techno-regulation. Experimenting with reputation and nudge’ 11(7) *Future Internet*, 163, (2019); N. Lettieri, ‘Law In The Turing’s Cathedral. Notes on the Algorithmic Future of the Legal Research’, in W. Barfield ed, *Cambridge Handbook on The Law Of Algorithms* (Cambridge: Cambridge University Press, 2020), 32-95; N. Lettieri et

of law and the science that studies it. The topic chosen is the naturalization of law, the tracing of legal phenomena back to natural ones. The process can be well connoted using Parisi's words: to naturalize implies adopting

‘a vocabulary of concepts, a theoretical framework, an “ontology” of entities, research methodologies, which do not assume a difference, a lack of homogeneity, a separation between the study of nature and the study of the phenomenon itself, between phenomena that can be “explained” and phenomena that can only be “understood”’.³

In other words, naturalizing the legal phenomenon⁴ means: i. studying it using ‘the same concepts used by the natural sciences or concepts defined in terms of concepts used by the natural sciences’;⁵ ii. thinking of it as ‘consisting of mechanisms and processes that are quantitative in nature and in which physical causes produce physical effects’; iii. reconstructing its ‘emergence over time from a previous state of the world in which it did not exist’.⁶

Today, the social sciences exhibit a pronounced tendency to dichotomize nature and society, employing conceptual and methodological tools vastly different from those of the natural sciences. Yet, bridging these two realms seems to be commendable for several reasons. Firstly, from an ontological perspective, the man-nature divide is at odds with the reality of an interconnected ensemble of phenomena, which are fully understandable only in their interrelations. Secondly, from an epistemological standpoint, this separation hinders our ability to comprehend humans, their behaviors, and societies.

The above also applies to law, where the bifurcation between nature and society not only obstruct a deeper empirical grasp of the real-world processes underpinning legal phenomena, but also hamper the formulation of legal solutions

al, ‘Knowledge mining and social dangerousness assessment in criminal justice: metaheuristic integration of machine learning and graph-based inference’ 31(4) *Artificial Intelligence and Law*, 653-702 (2023); Ead, ‘Keeping judges in the loop: a human-machine collaboration strategy against the blind spots of AI in criminal justice’ 27(16) *Soft Computing*, 1-19 (2023).

³ See D. Parisi, ‘Naturalizzazione della cultura’ *Montag*, 4, 19-35 (1998). Parisi puts forth a reflection in line with the growing attention paid, also on a philosophical level, to Naturalism. On this point see, among others, E. Agazzi and N. Vassallo eds, *Introduzione al naturalismo filosofico contemporaneo* (Milano: Franco Angeli, 1998); F. Laudisa, *Naturalismo* (Roma-Bari: Laterza, 2014); H. Price, *Naturalism without mirrors* (Oxford: Oxford University Press, 2010).

⁴ The expression is here used in an extremely broad sense to allude to a complex social fact in all its components and manifestations, encompassing everything from written norms to the cognitive processes underlying the emergence and diffusion of social norms.

⁵ In the anti-naturalistic perspective that permeates much of the human sciences, in fact, the separation between man and nature is used to legitimize the distinction between what can be studied scientifically (physical, chemical and biological phenomena) and realities (consciousness, moral values, laws etc) basically deemed incompatible with the empirical method based on direct observation, the formulation of hypotheses, experimental verification and mathematical demonstration.

⁶ D. Parisi, *Le sette nane. Una critica delle scienze dell'uomo e una proposta per un loro futuro migliore* (Napoli: Liguori, 2008).

grounded in a robust scientific comprehension of reality.

A cornerstone of our reflection, as hinted at in the title, is the role of computation in shaping the scientific understanding of the world we live in. We will argue that advancements in information science, technology, and computational methods open new avenues for approaching social (and, therefore legal) phenomena, enabling the integration of knowledge and the linking of various reality aspects which, as we have seen, are an essential precondition for reasoning in naturalistic terms. The project is ambitious, it is time to venture into the high open sea.

II. Computational Empiricism: On the Epistemic Role of Computation

The last decades have witnessed the spread of computation-based approaches in almost any area of science. Virtually every discipline, from physics to social psychology, has today a ‘computational counterpart’, a corresponding sub-sector extensively using algorithms to shed light on the phenomena it is interested in. As a matter of fact, along with the streams of data flooding our lives, computation - here understood not just as numerical calculation or algorithm implementation, but as any kind of automated information processing including symbolic reasoning or pattern recognition⁷ - is opening new frontiers to scientific investigation.

In such a scenario, one should question how computational and data-driven heuristics challenge established epistemologies. The relationship between science and computing has been a subject of discussion since the middle of the last century, when, during the Manhattan Project, the first digital computer saw the light. In that very moment, to use the words of John von Neumann’s chief engineer Julian Bigelow, ‘a tidal wave of computational power was about to break and inundate everything in science, and things would never have been the same’.⁸

Over the decades, contributions on this point have been countless with a sharp increase since the 2000s, after the explosion of Big Data and the spread of the computational science paradigm.⁹ On the other hand, issues to be addressed are numerous spanning from the reproducibility of experiments made with

⁷ P. Michelucci ed, *Handbook of Human Computation* (New York: Springer, 2016).

⁸ G. Dyson, *Turing’s Cathedral: The Origins of the Digital Universe* (New York: Pantheon, 2012).

⁹ See, within an ever expanding literature, P. Thagard, *Computational Philosophy of Science* (Cambridge: MIT Press, 1988); T. Tibor, *Computer Epistemology: A Treatise on the Feasibility of the Unfeasible or Old Ideas Brewed New* (Singapore: World Scientific, 1991); P. Humphreys, *Extending Ourselves: Computational Science, Empiricism, and Scientific Method* (Oxford: Oxford University Press, 2004); J.V. Segura, ‘Computational Epistemology and e-Science: A New Way of Thinking’ 19(4) *Minds and Machines*, 557 (2009); E. Winsberg, *Science in the Age of Computer Simulation* (Chicago: University of Chicago Press, 2010); R. Kitchin, ‘Big Data, New Epistemologies and Paradigm Shifts’ 1(1) *Big Data & Society*, (2014).

computational instruments¹⁰ or the limits of e-discovery¹¹ and the scientific value of the results produced by AI working with petabytes of high-dimensional data. Most of these problems are related to complex topics on the borders between the philosophy of science and technical - sometimes strictly mathematical - issues¹² that go far beyond the scope of this work. There are, however, some general epistemological questions it is worth dwelling on when pondering the perspective of any form of evolution in a naturalistic sense of legal science.

The question we wish to consider here is framed by Paul Humphreys in a volume offering a systematic philosophical account of computational research,¹³ and of how the latter is producing different approaches to the scientific method. Starting from research practices like agent-based simulations,¹⁴ Humphreys draws a parallel between the ways in which computational methods have enhanced our abilities to mathematically model reality and the more familiar ways in which scientific instruments have expanded our access to the empirical world. This enhancement is effectively qualified as ‘empirical extension’: similar to technologies that extend our perceptual abilities (think to the electronic microscope), and together with the data deluge, computation moves the boundaries between what is observable and what is unobservable.

If the word fact denotes real-world phenomena that can be somehow measured and linked in causal terms, then, in extending the ‘observational realm’, computation extends the realm of facts, thus paving the way to new forms of empirical investigation qualified by Humphreys as ‘computational empiricism’. Examples can be found in the possibility of detecting and analyzing previously inaccessible

¹⁰ R.D. Peng, ‘Reproducible research in computational science’ 334(6060) *Science*, 1226-1227 (2011).

¹¹ P. Langley, ‘The computational support of scientific discovery’ 53(3) *International Journal of Human-Computer Studies*, 393-410 (2000).

¹² D.H. Bailey et al, ‘Reproducibility in computational science: a case study: Randomness of the digits of Pi’ 26(3) *Experimental Mathematics*, 298-305 (2017).

¹³ P. Humphreys, n 9 above.

¹⁴ Agent-based social simulation models (ABSS) are a type of computational modeling used to understand and analyze social phenomena. This approach involves creating simulations in which individual entities, known as ‘agents’, interact within a defined environment according to a set of rules. Each agent in an ABSS model represents an individual or a collective entity (like a group, organization, or even a nation), and is typically characterized by a set of attributes, decision-making capabilities, and behaviors (among the others see, on this topic, J.M. Epstein, *Generative Social Science: Studies in Agent-Based Computational Modeling* (Princeton: Princeton University Press, 2006). ABSS models are led by the theoretical assumption that the macro-level social phenomena (eg, the emergence of social norms or the spread of racial segregation) are the result deriving from the interactions occurring, at the micro-level, between individuals and between individuals and the environment. ABSS models typically include several key components. First, a set of heterogeneous artificial agents simulates real-world actors and their behaviors. Second, there are rules of interaction that govern these agents. Finally, an environment is defined, encompassing dynamic, organizational, and spatial characteristics. Today social simulation provides policy-makers with the ability to run a what-if analysis allowing to observe the effects potentially deriving from different choices by means of well-developed models of a given ‘target system’ (see, for example, the effects of social stressors on patterns of political instability).

dimensions of reality from internal states of individuals (think sentiment analysis or computational analysis of neuroscientific data) to the dynamics occurring on social networks (think about the study of opinion dynamics on network models by means of simulation models).

The computational extension of the boundaries of ‘facts’, broadens the limits of what we can consider empirical research (and, therefore, natural science), increasing the variety of topics a given area of science can tackle. In light of this evolution, it becomes essential to decide where to steer our efforts. This is also true for legal scholarship, at least for that part of it that considers empirical investigation a challenge worthy of engagement.

However, despite the technical and practical advances, achievements in the research areas that have been most directly concerned with the intersections of law and information technology - from the early *Jurimetrics*¹⁵ to today’s *Computational legal studies*¹⁶ - have not brought substantial changes in the questions that scholars of the legal phenomenon ask themselves, in the way the goals and boundaries of legal science are conceived.

III. The ‘Empirical Shyness’ of Legal Scholarship

Legal science is, arguably, one of the areas of knowledge furthest from the natural science paradigm. Although with some exceptions, which we will discuss below, it can reasonably be argued that, overall, legal studies have always maintained a considerable distance from the methods, the questions and, above all, from the vision of reality that characterizes the natural sciences.

The statement largely stems from how the concept of law¹⁷ - and, consequently, of the science that studies it - has evolved over time. As a matter of fact, the history of Western legal thought reveals a trajectory where the interpretations of the legal phenomenon that have prevailed leave little room for empirical analyses and the

¹⁵ L. Loevinger, ‘Jurimetrics-The Next Step Forward’ 33 *Minnesota Law Review*, 455 (1948).

¹⁶ R. Whalen ed, *Computational Legal Studies: The Promise and Challenge of Data-Driven Research* (Cheltenham: Edward Elgar Publishing, 2020).

¹⁷ The problem of the concept of law, that is, of the determination of the elements that allow legal rules to be distinguished from other types of rules, is, to use Bobbio’s words, one of the ‘capital problems of the philosophy of law’ whose difficulty depends ‘by the breadth, multiplicity and complexity of the field of experience to which the jurist or legal philosopher turns his attention’. For this reason, the concept of law has taken on a different meaning over time depending on the observer’s point of view (scholar of private, public or international law, legal philosopher, sociologist, historian) and the historical moment. On this point, the scheme proposed by Bobbio is still current, cataloging the positions taken by jurists in this regard, highlighting how the typification effort has historically concentrated on a few fundamental characteristics of the legal norm: i) structure, ii) content, iii) purpose, iv) subject who establishes the rule, v) subject to whom the rule is addressed, vi) sanction (see N. Bobbio, ‘Diritto’, in A. Azara and E. Eula eds, *Novissimo Digesto Italiano* (Torino: UTET, 3rd ed, 1960), V, 769-776). Still on this point, for a more up-to-date overview, see, within an extensive literature, G. Fassò, *Storia della filosofia del diritto. III. Ottocento e Novecento* (Roma-Bari: Laterza, 2020).

model of a science built around the ‘sensible experiences’ and the ‘certain demonstrations’ Galileo put at the core of the scientific endeavour. Even with a thousand nuances, the answer to the question ‘what is law?’ has always gravitated around the idea of a system of written rules of conduct (the so-called *ius positum*) before which the *scientist* is called to perform work of interpretation and, at most, of systematization.¹⁸

Law, on the other hand, has an eminently practical function. Overall, it aims at building the conditions for an orderly conduct of collective life by defining canons of justice, prescribing behaviour, organizing cooperation, and administering sanctions for actions deemed harmful to the common good.

In the face of this, it is not surprising that legal science has assumed the prevailing character of a ‘practical’¹⁹ science, an area of study separate from other fields of knowledge that, using its own criteria and methods, aims more at ‘describing’ the system of norms for the use of scholars and practitioners by guaranteeing its interpretation based on verifiable logical procedures,²⁰ than at scientifically ‘explaining’ the characteristics and dynamics of legal phenomenon seen as fact and read in terms of processes occurring on levels of reality outside the normative one. Such a circumstance is confirmed in the debate on the scientific nature of legal studies that began when jurists began to seriously engage with the natural sciences and the achievements resulting from the practice of the scientific method.

Symbolically started around the middle of the 19th century by the legal

¹⁸ One of the most compendious definitions of law is probably the one offered more than a century ago by François Gény: ‘a set of rules to which man’s external conduct in his relations with his fellow men is subject, which, under the inspiration of the natural idea of justice [...] and, appearing susceptible of social and perhaps coercive sanction, are or tend to be provided with such sanction and from this time forward are placed in the form of categorical commands dominating the particular wills to secure order in society’, F. Gény, *Science et technique en droit privé positif: nouvelle contribution à la critique de la méthode juridique*, I (Paris: Recueil Sirey, 1912), 51.

¹⁹ The connection with practical interests and objectives is also highlighted, with reference to the social and human sciences in general, by Parisi: ‘in the human sciences, the connection between knowledge and practical interests is stronger and has a deeper impact on the nature of the disciplines and theories.[...] the human sciences are immediately focused on the practical problems of human beings, so much so that in them sometimes there seems to be no disinterested space for knowledge before one even thinks about using it for practical purposes’, see D. Parisi, *Simulazioni: la realtà rifatta nel computer* (Bologna: Il Mulino, 2010), 130.

²⁰ In the last century there has been no shortage of anti-formalist positions fighting the idea of a legal science essentially oriented towards exegesis and systematization of sources. One of the more recent and authoritative expressions of this interpretation of law and the role of the jurist can be found in the work of Paolo Grossi, who strongly opposes the ‘prison of exegesis’ in which the jurist is often forced by assigning the latter an active role in understanding the reality to be regulated. According to Grossi, jurists also have the fundamental task of ‘reading the signs of the times, flexibly following the very rapid movement and change, noting the gaps that evolution has generated’, a reading which in some way underlies needs similar to those that animate the proposal of naturalization presented in these pages. On this point see P. Grossi, *Società, diritto, stato: un recupero per il diritto* (Milano: Giuffrè, 2006). Along the same lines, see Id, *Mitologie giuridiche della modernità* (Milano: Giuffrè, 2007).

philosopher Von Kirchmann with the *pamphlet* 'The lack of value of jurisprudence as a science',²¹ the reflection raises issues still relevant today, yet far from being satisfactorily resolved.

Despite the quantity and variety of contributions accumulated over time, to paraphrase what Parisi said about the relationships between philosophy and complexity science, legal research uses 'outdated reference frames and does not take into account theoretical and methodological developments in science that would be of great importance'.²²

Upon closer inspection, the point is not - for many aspects - the abstract transferability of natural science methods into the legal domain. The point is, similarly to what happens in other areas of the social sciences, to reflect adequately on the meaning and possible configuration of the relationship that can be established between the natural sciences, the legal regulation of social life, the study of *ius positum*, and the perspective of an empirical science of the legal phenomenon in line with the knowledge and vision of the world that the progress of science offers us today.

IV. The Troubled Relationship Between Law and the Natural Sciences

The projection towards the natural sciences is not, in an absolute sense, a new phenomenon in the history of legal thought. Ever since the scientific method revealed its revolutionary ability to illuminate the fundamental laws of the universe, more than one jurist has recognized Galileo's science as a model from which to draw on a scientific or methodological level. This deserves a brief mention at least to offer at my arguments a dialectical reference term.

The first manifestations of this interest date back to the 17th century, when the methods of the new 'natural philosophy' began to be perceived by the exponents of the 'natural law' as possible allies in the opera of discovering 'Natural law', the set of transcendent principles of justice and rationality that natural law scholars believed they had to scientifically investigate in order then to transpose them into the discipline of real life.

Hugo Grotius, the father of 'modern natural law', is probably the first and most significant representative of this line of thought. Having put aside the idea of a system of rules resulting from the will of a God-person, the 'Natural law' becomes for him a fact of nature knowable, as such, through the exercise of reason and the language of science. It is no coincidence that in *Prolegomena* of the *De iure belli*

²¹ The statement is well known: 'Insofar as the science of law takes the contingent as its object, it becomes contingent itself: three words of rectification from the legislator, and entire libraries become waste paper' (see J.H. Kirchmann, *Die Wertlosigkeit der Jurisprudenz als Wissenschaft*, Italian translation: *La mancanza di valore della giurisprudenza come scienza* (Berlin: Julius von Springer, 1848).

²² See D. Parisi, 'Ritardi della filosofia' *Rivista di filosofia*, 413-454 (2000).

ac pacis,²³ the treaty of international law to which his fame is mainly due to, he declares to have used the methods of mathematical physics to root the identification of the principles of natural law presented in his work in a rigorous logical path.

Thomas Hobbes, another exponent of the 'Natural law' school,²⁴ goes somewhat further. Indeed, his doctrine of the State is rooted not only in the Galilean theory of motion and mechanics, but also in another natural science, modern physiology emerging in those years,²⁵ which becomes an additional source of metaphors for conceptualizing the dynamics of law and imagining new forms of regulation of human societies.

The assumption for which natural sciences constitute the founding model for a new legal science continued throughout the eighteenth century. Accompanied by the suggestions of a Newtonian physics that quickly became a reference for all social sciences,²⁶ the 'naturalist' perspective continued to be a source of inspiration for several jurists. The Scottish Enlightenment thinkers David Hume and Adam Smith, to mention two significant names, also went as far, albeit with different motivations, as to vague a science of human nature that applied Newton's view of reality and experimental method to law (as well as morality and politics).²⁷

²³ Grotius speaks of 'demonstrations' founded on 'notions so evident that no one can deny them without doing violence to himself'. The method is described in more detail by Grotius in *De jure predae*: 'as mathematicians usually preface every concrete demonstration with a preliminary formulation of certain broad axioms (*some common... ideas*) on which all people easily agree, in order to have some fixed point from which to proceed in the following proof, so we will also indicate certain rules (*regulations*) and read (*laws*) of the most general kind, presenting them as preliminary assumptions that must be recalled, rather than learned for the first time, in order to lay a foundation on which our other conclusions can confidently rest'. See H. Grotius, *De jure belli ac pacis*, translation by F.W. Kelsey (Oxford: Clarendon Press, 1925), 29-30.

²⁴ The use of mathematical language and metaphors coming from the natural sciences is a characteristic feature of the entire modern natural law theory. Thomasius, philosopher and jurist who authored, in 1707, a German translation of the *De iure belli ac pacis*, argued that the natural law scholars Hugo Grotius, Thomas Hobbes and Samuel Pufendorf had distinguished themselves precisely for having applied mathematical reasoning to natural law, even going so far as to state that 'a non-mathematician could never hope to understand the science of natural law'. The works of other fundamental authors can be traced back, with all the needed differences, to the same cultural background: the *Ethica more geometrico demonstrata* from Baruch Spinoza and the *Specimen demonstrationum politicarum* by Leibniz, two works in which logic and probability calculation become an integral part of the analysis. On this point see the very interesting work carried out in I.B. Cohen, *Scienze della natura e scienze sociali* (Bari: Laterza, 1993), 129.

²⁵ We refer here to the work of William Harvey, an English doctor known for being the first scholar to accurately describe the human circulatory system and the properties of blood. Hobbes also drew heavily on Harvey's discoveries, which must have had a special importance for him as they were based on mathematics, ie, on quantitative considerations.

²⁶ The summary proposed by the political scientist and historian is indicative J.S. McClelland: 'in the Enlightenment, everybody wanted to be the Newton of the social sciences. Find the axioms of human nature, deduce from them in the approved Newtonian manner, and a complete science of man became a possibility'. J.S. McClelland, *A history of western political thought* (London: Routledge, 2005), 280.

²⁷ M.G. Barberis, *Giuristi e filosofi. Una storia della filosofia del diritto* (Bologna: il Mulino, 2011), 93.

However, the dialogue between legal and natural sciences softened at the end of the Enlightenment, shifting towards objectives that appear less radical when compared with the ambitions of natural law scholars in the face of the achievements of Galilean science. At the turn of the nineteenth and twentieth centuries, the influence of natural science on the legal science takes on new connotations: pushing towards the study of factual aspects of the legal phenomenon, encouraging openness to empirical and quantitative methods of inquiry, and fostering dialogue with other disciplines, but no longer touching, in explicitly naturalistic terms, on the conception of law and the science that is to study it. The currents of *Realism*²⁸ and of *Empirical Legal Studies*²⁹ or, again, the Sociology of law,³⁰ are representative examples of this change of pace.

Overall, the sketched picture leaves no room for doubt: the idea that law is a part of the natural world that can be explored by drawing on the vision of reality, the acquisitions and methods of the natural sciences have had limited follow-up. The naturalistic impetus of Grotius and his successors has basically exhausted itself in the adoption of the deductive axiomatic method, while the more empirically oriented declinations of legal studies have never gone so far as to consider as a possible starting point of their inquiry an explicit location of law within nature.

To date, while there is no shortage of areas of study investigating law-relevant phenomena from the perspective of the natural sciences - think of the strand of

²⁸ The expression refers to two connected currents of thought: the *Scandinavian realism*, aimed at exploring the impact exerted by individual psychological attitudes and the social context on the mechanisms of application of the rules and the *American legal realism*, movement born in American law faculties with the idea of extending the rigor of the scientific method to the study of the fundamental concepts of law. Among the most significant works of the Scandinavian realism see, A.A.T. Hägerström and M.F.S. Fries, *Socialfilosofiska uppsatser. Med inledning av Martin Fries* (Stockholm: Albert Bonniers Förlag, 1939); A. Ross, *On Law and Justice* (London: Stevens & Sons, 1958); K. Olivecrona and C.D. Broad, 'Inquiries into the Nature of Law and Morals' 30(115) *Philosophy*, 369-373 (1955). On the *American legal realism* see, O.W. Holmes Jr., 'The path of the law' 10(8) *Harvard Law Review*, 457-478 (1897); K. Llewellyn, 'A realistic jurisprudence - the next step' 30(4) *Columbia Law Review*, 431-465 (1930); J. Frank, *Law and the Modern Mind* (New York: Routledge, 1930).

²⁹ Relatively new approach to the study of law which explicitly lists among its objectives the experimental and empirical investigation of legal questions. Developing in the United States over the last ten years, the movement of *Empirical Legal Studies* is characterized by a highly interdisciplinary research perspective. It is no coincidence that, among the objectives of the Society for Empirical Legal Studies, there is the promotion of 'conversations among scholars in law, psychology, sociology, economics, political science, criminology, finance, health care, and other disciplines'. For an interesting overview of the topics covered in the area of Empirical legal studies, see P. Cane and H. Kritzer eds, *The Oxford handbook of empirical legal research* (Oxford: Oxford University Press, 2012).

³⁰ Area of legal studies which, to use the Renato Treves words, aims to investigate 'on the one hand the problem of society in law, that is, social behavior that conforms or differs from the norms, of the so-called "effective" legal reality, which can act as an indicator of a free, latent, living or developing right; on the other hand, the problem of law in society, that is, that of the position, function and purpose of law in society seen as a whole', see R. Treves, *Sociologia del diritto: origini, ricerche, problemi* (Torino: Einaudi, 1987), 5.

research on the borders between neuroscience and law³¹ - no front in the modern 'naturalistic' sense of the science of legal phenomenon has yet been opened. The time, as we will show, is now to move in this direction and, in this paper, the time has come to fill this proposal with content and reasons.

V. Thinking of Law as a Natural Phenomenon

The hypothesis of a naturalization of legal science is not a trivial one. Without using hyperbole or adhering to a specific philosophy of science perspective, it can be argued that the adoption of a modernly naturalistic approach to the legal phenomenon is a choice that affect constituent elements of the primary identity of legal science, those same aspects that, in Kuhn's (2009) vision, define the concept of a scientific paradigm:³² the reference ontology; the research questions; the techniques and tools of inquiry as well as the solutions deemed valid.

It will not seem nonsensical, therefore, if, before delving into the merits of such a radical hypothesis, we spend some time delineating the boundaries of the proposed idea, particularly in clarifying the relationship it should have with what legal science already encompasses as a whole today. From this perspective, it is important to specify that the proposal outlined in these pages does not intend to deny the validity of the legal science model currently followed by the majority of scholars and practitioners of law, regardless of the legal system under consideration. Law is a *social technology* which, as we have seen, has the eminently practical function of enabling the orderly conduct of social life and directing the latter toward shared and socially desirable ends.

In the light of this, the persistence of a legal science-*scientia legum*, an area of study primarily focused on exegesis, the systematization of legal sources (rules, case law etc) and the reflection around the formal criteria of production of the latter makes and will continue to make sense.³³

The real issue lies elsewhere. Beneath the *surface* of positive law, its sources

³¹ The literature on the subject is now very extensive. Among the first works on the topic see M.D. Freeman and O.R. Goodenough eds, *Law, Mind and Brain* (Farnham: Ashgate Publishing, 2009); O.R. Goodenough and M. Tucker, 'Law and cognitive neuroscience' *6 Annual Review of Law and Social Science*, 61-92 (2010). For an updated overview of the subject matter, see among others, in Italian, G. Bombelli and A. Lavazza eds, *Law and Neuroscience. New Perspectives* (Sesto San Giovanni: Mimesis, 2021).

³² Identifiable, to use Kuhn's own words, with a 'model of problems and solutions acceptable to those who practice a certain field of research', see T.S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 2012), 10.

³³ It is worth recalling here the consideration made by Carlo Rovelli on the possible coexistence of the naturalistic approach with other forms of study of reality: 'Law, aesthetics, morality, logic, psychology... are autonomous sciences. But the assumptions of these disciplines and the realities they deal with do not contradict naturalism, because they can be traced back to the general coherence of the natural world, just as chemistry is compatible with physics: our thinking and our inner life are real phenomena, generated from us, natural creatures in a natural world, C. Rovelli, 'Siamo creature naturali in un mondo naturale' *Domenica del Sole 24 Ore*, 14 December 2014.

and mechanisms of action, phenomena belonging to different levels of reality³⁴ (from that of individual cognition to that of institutions) are stirred and interact with each other, all phenomena that, although traditionally brought back to the domain of the natural sciences, play a decisive role in the genesis, manifestation and evolution of what happens on the legal level. It is therefore essential to recontextualize and study them within a coherent theoretical and research framework.

On the other hand, one of the hallmarks of natural science, is the attempt to explain phenomena that take place on one level of reality in terms of processes that take place on other levels. So does physics, so have chemistry and biology.³⁵

The legal phenomenon is not exempt from this multi-layered interpretation of reality: it too unfolds across various levels of reality, and understanding it requires identifying and studying these layers. From this perspective - this is our main claim - , it is not unreasonable to regard law as an integral part of the natural world, inclusive of all phenomena that shape its characteristics.³⁶ This holds true despite the fact that law primarily presents itself as an artifact, a deliberately crafted tool designed to achieve a specific purpose.

The challenge, essentially, is to reconnect law with nature, to address what Huw Price – author of one of the most recent and insightful epistemological contributions on the subject of naturalism – defines as the ‘problem of placement’,³⁷ the issue of where to *position* in relation to the natural sciences entities such as law, moral values, or conscience, which seem alien to the world described by physics and other sciences studying nature.

Upon reflection, the decision to place law within the category of natural phenomena (with all that entails in terms of methodology and the willingness to discover other levels of reality within it),³⁸ has more than one rationale. A turn in

³⁴ Think, among others, of the biological and cognitive mechanisms underlying legally relevant individual choices currently studied by cognitive sciences, neurosciences and behavioral sciences or, again, the collective dynamics investigated by computational social sciences and sociophysics and capable of influence the operation of legal rules.

³⁵ A quintessential example of this approach in the natural sciences is provided by Erwin Schrödinger’s seminal essay, where he first explores the concept of explaining life - specifically the genetic transmission of hereditary traits - through quantum phenomena. This work essentially paved the way for the emergence of molecular biology (see E. Schrödinger, *What is Life? The Physical Aspect of the Living Cell* (Cambridge: Cambridge University Press, 1944).

³⁶ Words used by Daniel Dennett in his attempt to build a naturalistic approach to religion apply here: ‘I might mean that religion is natural in the sense that it is not supernatural, a human phenomenon made up of events, organisms, objects, structures, forms and the like, which obey the laws of physics or biology [...] religion, as a complex set of phenomena, is a completely natural phenomenon[...] But smoking, war and death are also natural. In this sense of natural, everything artificial is natural! The Aswan Dam is no less natural than a beaver dam[...] natural sciences take as their object every aspect of nature, and that means jungles and cities, birds and airplanes’, see D.C. Dennett, *Breaking the Spell: Religion as a Natural Phenomenon*, (London: Penguin, 2006).

³⁷ H. Price, *Naturalism without Mirrors* (Oxford: Oxford University Press, 2010), 6.

³⁸ The drive to ‘dig’, to seek new levels *inside of* observed reality, is a distinctive feature of natural science well exemplified by the search for the ultimate components of matter which has driven physics from the atomism of Democritus to quantum theory. The investigation of the

this direction is not justified only, in ontological terms, by a stance regarding an intrinsic quality – being natural - of the object of study. The possibility of tracing back a phenomenon to the category of ‘natural’ things is also a function of the concrete possibility of observing, measuring,³⁹ empirically investigating, and experimentally exploring it.

In a similar perspective, any phenomenon that can be measured, modelled, experimented and, in a broad sense, explored with the methods of natural sciences becomes ‘natural’. Today, the perimeter of what can be studied ‘naturalistically’ has greatly expanded and included many of the phenomena that are at play beneath the surface of law evoked earlier. The factors behind this expansion are diverse and lie as much on a scientific and methodological level as on the broadly instrumental-technological one.

From the scientific point of view, a first driving factor for the hypothesis of naturalizing law here proposed is represented by the enormous strides made in understanding ‘non-legal’ levels of reality on which law-relevant phenomena occur. A good example in this sense is the insights gained by cognitive sciences regarding individual and collective mental processes underlying legal phenomena or involved in the formation of the law itself such as the so-called *opinio iuris ac necessitatis* in the case of custom. A similar argument can be made for the results achieved in other research areas, from behavioral sciences to the emerging field of computational social sciences.⁴⁰

The availability of a growing body of sectoral scientific knowledge is not the most relevant factor for the construction of the approach to law that we are hypothesizing. A much more significant factor is represented by complexity theory,⁴¹

fundamental structure of things translates, to use Heisenberg’s words, into looking ‘beyond the surface of atomic phenomena, [in search of] an innermost level of mysterious beauty’ (see W. Heisenberg, *Physics and beyond. Encounters and Conversations*, (New York: Harper & Row, 1971), 81). In some way, this is the thesis proposed here, the same thing can be done with law: broaden the notion that defines it by discovering the levels of reality, the phenomena of which it is literally ‘made’; things that today, unlike in the past, we can understand and connect based on the image of the world provided by modern science.

³⁹ Without stretching the bounds, we can quote what Max Planck claimed about the role of the progress of observation and measurement systems with respect to the development of science: ‘if we cast a retrospective glance at the road along which physics has proceeded so far, we must admit that further progress will depend essentially on the development and wider application of our methods of measurement’, see M. Planck, *The Image of Science, Essays on Modern Physics* (Castelvecchi: Roma, 2018), 44.

⁴⁰ C. Cioffi-Revilla, ‘Scienza sociale computazionale e scienza giuridica’, in S. Faro et al eds, *Diritto e scienze sociali computazionali* (Napoli: Edizioni Scientifiche Italiane, 2011); E. Fabiani et al eds, *Diritto, neuroscienze, scienze della cognizione* (Napoli: Edizioni Scientifiche Italiane, 2014); L. Cominelli, *Cognizione del diritto: per una sociologia cognitiva dell’agire giuridico* (Milano: Franco Angeli, 2016).

⁴¹ Over the past two decades, the conceptual vocabulary of complexity theory has seeped into an increasingly broader part of social science. The spread of concepts such as ‘emergence’, ‘non-linearity’, ‘non-equilibrium dynamics’ or ‘phase transitions’ has triggered not only important theoretical revisions, but also reformulations on a methodological level. For an overview of the ongoing process, see D. Byrne and G. Callaghan, *Complexity theory and the social sciences: The*

a frontier area of science that is uncovering the laws that surprisingly unite the behavior of processes that take place, at vastly different scales, wherever systems made up of sets consisting of a tendentially large number of interacting elements materialize. Because of their inherent characteristics - non-linearity, unpredictability, self-organization, emergence⁴² - complex systems have long remained outside the tractability boundaries of Newtonian and deterministic science.

Today, complexity science is refining a valuable toolkit for understanding the structure, behaviour and dynamics of change in complex systems: a theoretical framework and methodological apparatus capable of profoundly transforming the understanding of the world at different ontological levels, from the fundamental mechanics of the human brain to the innumerable manifestations of social complexity of which law is a part.

For legal science, engaging with complexity theory can have a revolutionary effect. Some experiences of this kind of engagement have already taken place. However, the outlook on the 'legal complexity', has so far resulted in the adoption of concepts and methods from physics for the study of *legal document corpora*.⁴³

Still almost entirely absent is a research perspective geared toward embracing the conceptual and methodological vocabulary of *complexity science* to interpret (first) and investigate (then) the processes underlying the 'law-norm'. The adoption of a *complexity-inspired* perspective⁴⁴ should lead to broadening the 'static' conception of law seen as a one-dimensional object, with that of a phenomenon that develops on different levels (cognition, behavior, society) connected by action and feedback cycles to be explored in new ways.⁴⁵

On the other hand - and this is the third and final argument - the naturalization of law finds support from ideal conditions on the methodological and instrumental level.⁴⁶ Computational social science - an area of study that brings together the

state of the art (London: Routledge, 2013).

⁴² For an introduction to the properties of complex systems and, more generally, to complexity theory see, in Italian, A. Pluchino, *La firma della complessità: una passeggiata al margine del caos* (Catania: Malcor D', 2015).

⁴³ J.B. Ruhl et al, 'Harnessing legal complexity' 355(6332) *Science*, 1377-1378 (2017).

⁴⁴ M. Xenitidou and B. Edmonds eds, *The Complexity of Social Norms* (Cham: Springer, 2014).

⁴⁵ The interaction between different ontological levels is one of the characteristic features of complex systems and this obviously also applies to the social systems of which law is an expression: 'complex social systems are characterised by multiple ontological levels with multidirectional connections, proceeding not only from the micro to the macroscopic levels but also back from the macro to the micro-levels', see R. Conte et al, 'Manifesto of computational social science' 214(1) *The European Physical Journal Special Topics*, 325-346 (2012); D. Helbing et al, 'Social Systems and Complexity' 11(4) *Advances in Complex Systems*, 485 (2008).

⁴⁶ The availability of adequate investigation methods and tools (here referring to mathematical tools in the strict sense) is an important conditioning factor in the dialogue between social sciences and natural sciences. *Political Arithmetics*, an economic-social discipline born at the beginning of the 17th century at the hands of William Petty and aimed at extending to the social sciences the new ideas and the conception of the world that were establishing in the natural sciences, failed essentially because the mathematical methods used by physics in the seventeenth century were not suited to the study of social phenomena. Arithmetic and algebra were not enough, probability

complexity theory *framework*, social sciences questions and the computational science paradigm - now provides an apparatus of research methods and practices that can open up entirely new horizons for scientific understanding of the social world. Computer simulation, complexity models and *network analysis*⁴⁷ are only one part of an ever-evolving toolkit fueled by the growth of available computing power, the datafication process of an ever-larger part of our lives⁴⁸ and, not least, advances in artificial intelligence.

In conclusion - we have somewhat already highlighted it above - computers and data, *data-driven* heuristics and computational models extend the boundary of phenomena that can be detected, measured, simulated and causally connected; the boundary, ultimately, between what can be treated as nature and what it cannot.

VI. Making Wings for the ‘Mad Flight’

The endeavor to align legal science with the model of natural sciences is a project worthy of significant intellectual and scientific effort. This belief is supported by several reasons.

The first is purely scientific. The broadening of the phenomenological horizon of legal studies and the adoption of methods belonging to natural science understood in its broadest sense, from neuroscience to complexity theory, open new scenarios that go beyond the scientific understanding of the legal organization of human societies. The research topics of a naturalized legal science (eg the individual and collective cognitive dynamics underlying the interplay between legal and social norms)⁴⁹ are relevant only to the legal domain,⁵⁰ but to all social sciences.

calculation and infinitesimal calculus which were only just emerging then would have been needed. On this point see I.B. Cohen, n 24 above, 136.

⁴⁷ C. Cioffi-Revilla, *Introduction to computational social science* (London-Heidelberg: Springer, 2014).

⁴⁸ Most of computational social science is based today on the use of techniques *data mining* in line with the paradigm described, in 2009, in D. Lazer et al, ‘Computational social science’ 323(5915) *Science*, 721-723 (2009). There is still however much to explore in the potential integration between the *data-driven* approach and the *model-driven* one, a vision of a social science oriented towards using computation to develop new theoretical models (mainly agent-based generative simulation models in the perspective outlined by Joshua Epstein) of the processes underlying social complexity. A very interesting proposal on this point is presented in R. Conte et al, n 45 above. For an introduction to the paradigm of *generative social science* you are in J.M. Epstein, n 14 above.

⁴⁹ Other topics of potential interest are the processes underlying the emergence of legal norms, the interactions between regulatory policy choices and social dynamics or, again, the unwanted social effects potentially deriving from the introduction of a legal norm.

⁵⁰ The world of law has already shown sensitivity to the broad category of topics just mentioned. There would be many names to mention. By way of example only, see here R. Ellickson, *Order without law: How neighbors settle disputes* (Harvard: Harvard University Press, 1991); E.A. Posner, *Law and Social Norms* (Harvard: Harvard University Press, 2009); R. Sacco, *Il diritto muto. Neuroscienze, conoscenza tacita, valori condivisi* (Bologna: il Mulino, 2015); M. Svensson, ‘Norms in law and society: towards a definition of the socio-legal concept of norms’, in *Social and Legal*

For legal scientists, naturalization could represent a new response to the need for ‘recovery of the factual and social dimension’⁵¹ of the legal phenomenon repeatedly invoked but always overwhelmed by the formalist reading of law still dominant today. For social scientists, the availability of gradually more refined models of how law emerges, evolves, and operates could turn into the possibility of enriching⁵² their theories and models with an explicit representation of a level of reality, the legal one, which significantly impacts social dynamics.

Naturalisation, in any case, does not only represent an opportunity to transcend the paradigm that, at present, rules the legal and social worldview. In perspective, it opens up to legal systems, to *policy* and *rule-making*, the possibility of rooting their choices in an gradually deeper knowledge of the phenomena being regulated.

Taking it to the extreme, seen as an artifact through which societies devise responses to the problems they face at all levels, from that of a state’s fiscal policies to the global level of climate change, law is ‘technology without science’.⁵³ Legal culture lacks a projection towards a scientific study (in the sense alluded above) of what law is and how it interacts with the social reality from which it comes and on which it is intended to operate. Without such an understanding, everything becomes more difficult: pronouncing empirically grounded value judgments about the goodness of regulatory choices and, above all, working out regulatory solutions not as something that happens *off-line* outside the social and factual context of intervention, but as a constitutive process that interacts with the self-organized behavior of the context itself.⁵⁴

A legal norm, on the other hand, can be seen as a single system together with the social reality that is object to intervention. In such a view, the outcome of a regulatory intervention (whether it comes from laws, administrative acts or even

Norms (London: Routledge, 2016), 39–52). None of these reflections, however, takes into consideration, as a basic epistemological option, the projection towards the natural science paradigm.

⁵¹ P. Grossi, n 20 above.

⁵² The idea is well summarized in a recent work by Cristiano Castelfranchi who theorizes a ‘science of layered mechanisms’, a scientific model described in these terms: ‘we need several different layers of “theory,” in particular for understanding human behavior. These layers should concern: the cognitive (mental) representations and mechanisms; the neural underlying processes; the evolutionary history and adaptive functions of our cognition and behaviors; the emergent and complex social structures and dynamics, their relation and feedbacks on individual minds and behaviors, and the relationship between internal regulating goals and the external functions/roles of our conduct; the historical and cultural mechanisms shaping our minds and behaviors; the developmental paths’. See C. Castelfranchi, ‘For a science of layered mechanisms: Beyond laws, statistics, and correlations’ 5 *Frontiers in Psychology*, 536 (2014).

⁵³ What has been said does not overlook the value-based and political choice component inherent in legal regulation, namely the decision expressed by a given community regarding what may be considered just and desirable at a particular historical moment. The idea is simply to highlight the profound connection that this political and value-based evaluation maintains with the empirical understanding of the factual context from which it originates and on which the regulation is intended to operate.

⁵⁴ F. Squazzoni, ‘A social science-inspired complexity policy: Beyond the mantra of incentivization’ 19(6) *Complexity*, 5–13 (2014).

judicial decisions) is a function not only of the abstract, separately defined characteristics of the regulatory instrument and the factual context. The evolution of the system (the outcome of regulatory choices) is the result of the often complex and counterintuitive way, in which regulation and context interact.⁵⁵ Because of this, it can be much better understood, and evaluated in terms of its compliance with legally defined values and principles, with the support of a genuinely scientific investigation.⁵⁶

The stakes are high. A scientific understanding of the complexity to which law gives rise together with the phenomena itself tries to order is an important condition for freeing public discourse and policy choice from fallacious representations of reality and coping more consciously with the challenges looming over the globalized, technological, and interconnected society we live in.⁵⁷

It remains clear, in any case, that the naturalization of legal science is an ambitious project of not immediate realization. It presupposes a series of changes that involve the cultural-scientific identity of the legal scholar to an extent that goes far beyond the willingness to rethink the legal phenomenon as part of nature. The list of what is required of the ‘jurist-naturalist’ of the future is long: to familiarize with the worldview and the complexity theory conceptual vocabulary by opening himself to all the areas of scientific knowledge (from social psychology to the theory of evolution) with which the latter prompts dialogue; to adopt a methodologically eclectic, issue-oriented research style, oriented toward a creative use of theoretical constructs from other disciplines; project himself towards an empirical and quantitative reading of legal phenomena; to rethink the problems under study and his research questions in computational terms; and to prepare himself to design and experiment, together with other categories of scholars, new research tools and methods.

Added to all this is the need for careful reflection with an epistemological slant, a prerequisite for giving awareness to a project which, in essence, moves

⁵⁵ The *Tragedy of the Commons*, the social dilemma theorized by Hardin (G. Hardin, ‘The tragedy of the commons: the population problem has no technical solution; it requires a fundamental extension in morality’ 162(3859) *Science*, 1243-1248 (1968)) and which became the focus of Elinor Ostrom’s research (E. Ostrom, *Governing the commons: The evolution of institutions for collective action* (Cambridge: Cambridge University Press, 1990)), is a significant example of the type of scenario just mentioned. The evolution of the dilemma, which law also aims to govern, is indeed influenced by dynamics - such as the interaction between the mechanisms of intertemporal choice and selfish rationality - that science is increasingly shedding light on. On this point see, by way of example, J. Jacquet et al, ‘Intra- and intergenerational discounting in the climate game’ 3(12) *Nature Climate Change*, 1025-1028 (2013).

⁵⁶ N. Lettieri, *The legal macroscope* n 2 above; Id, *Law In The Turing’s Cathedral* n 2 above.

⁵⁷ From this perspective, it is suggestive to think of the law produced by a naturalized legal science as an instrument capable of better contributing to the construction of what has recently been defined as ‘planetary-scale intelligence’ (see A. Frank et al, ‘Intelligence as a planetary scale process’ 21(2) *International Journal of Astrobiology*, 47-61 (2022)): the ability to build a coordinated global response to potential existential threats through the acquisition and application of collective knowledge on a planetary scale.

asymptotically toward the construction of what Niels Bohr called ‘unity of knowledge’ understood as the ‘harmonious understanding of increasingly vast aspects of our condition’⁵⁸ to be sought as an almost inevitable consequence of the ‘unity of nature’.

To do all this, what we need is a research agenda, a program devoted, with the necessary degree of openness and radicality, to the exploration of foundational, basic research issues which would today be difficult to find a satisfactory placement in the current disciplinary organization of research and academy, especially in Italy. In this perspective, a structure similar in spirit to the *Foundational Questions Institute (FQxI)* (the institute founded in 2005 by Max Tegmark to support basic research in the foundations of physics and cosmology with regard to ‘visionary and pioneering’ frontier topics) would be needed.

Creating such an entity clearly constitutes a daunting task, a challenge reminiscent of the ‘mad flight’ Ulysses talks about in the XXVI *Canto*. On the other hand, it foreseeably requires multiple and significant efforts: thinking radically; forging networks of ideas and people across disciplines, and, above all, constantly striving to extend the vision further, asymptotically ahead. For all the reasons above, it seems to be a worthy commitment, an endeavour any inspired researcher would persist in doing until the very end.

⁵⁸ N. Bohr, *I quanti e la vita: Unità della natura. Unità della conoscenza* (Torino: Bollati Boringhieri, 2016).