THE MILLIAN MODEL OF SCIENTIFIC EXPLANATION

CONSTANTIN STOENESCU

Abstract. A detailed historical reconstruction of the model proposed by Mill on scientific explanation reveals the fact that it anticipates most of the basic ideas in the philosophy of science, from Popper to Hempel, from the idea of explanation through "covering laws" to that of theoretical unification. Mill develops his model starting from Hume's problem of the possibility of a causal explanation. Guided by the principles of an empiricist epistemology, Mill proposes a theory of deductive explanation of the laws of nature simultaneously with a critique of deductive reasoning. The purpose of this research is to go into the details of Mill's project and to justify it based on his own assumptions.

Keywords: John St. Mill, David Hume, causal explanation, deductive explanation of laws, Mill's deductive method

REDISCOVERING JOHN ST. MILL'S PHILOSOPHY

The traditional image of Mill's contributions to the philosophy of science was the one established by Bertrand Russell in *A History of Western Philosophy*, that of an old-fashioned philosopher who was devoted to the old problem of induction in a completely obsolete manner used by Francis Bacon in his remarks about the so-called "induction tables"[1]. It is true, Mill himself denigrated his scientific skills, confessing his superficiality and ignorance in the field of mathematics

Constantin Stoenescu ✉
Faculty of Philosophy, University of Bucharest
E-mail: constantin.stoenescu@filosofie.unibuc.ro

[1] Russell harshly judges John St. Mill on his contributions to logic (see Bertrand Russell, "John Stuart Mill", in J.B. Schneewind (ed.), *Mill: A Collection of Critical Essays*, New York, Anchor Books, 1951, p. 2), and in the *History of Western Philosophy* he gives only a few critical lines in relation to his research on the inductive method, but these occur in the chapter dedicated to Bacon, because when he deals with Mill he will retain him only for his contributions to the utilitarian theory. (See Bertrand Russell, *History of Western Philosophy*, London and New York, Routledge, 1996, p. 500, pp. 702–703).

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and experimental science[2]. In this regard, to emphasize the obsolescence of Mill's philosophy, some compare him with a contemporary rival, William Whewell, a much better *connoisseur* of the scientific achievements[3]. However, although educated to look first to the past[4], apparently paradoxically, John St. Mill anticipated some of the problems in the fields of epistemology and philosophy of science, which forces us to reconsider his work and to recognize that "Mill possessed the ability to go beyond the confines of false and inadequate theories and penetrate them to important new insights"[5].

My goal in this paper is to go into the details of Mill's work and to bring to attention those aspects that are current in contemporary debates on scientific explanation. In their famous paper "Studies in the logic of explanation", Carl G. Hempel and Paul Oppenheim mention in a footnote that although their account of the general characteristics of explanation and prediction in science is a new one, "it merely summarizes and states explicitly some fundamental points which have been recognized by many scientists and methodologists"[6]. The first thinker mentioned in historical order is John St. Mill, being identified in a defining passage that anticipates their so-called covering law model of explanation:

> An individual fact is said to be explained, by pointing out its cause, that is, by stating the law or laws of causation, of which its production is an instance. (…) And in a similar manner, a law or uniformity in nature is said to be explained, when another law or laws are pointed out, of which that law itself is but a case, and from which it could be deduced[7].

Many others strengthened this historical recovery of Mill in relation to the nomological-deductive or covering law model of scientific explanation so that it became a trivial truth beyond any doubt and which no longer needs to be investigated. Although, according to Wesley C. Salmon's narrative, philosophers before the appearance of the model proposed by Hempel and Oppenheim "had no

[2] John St. Mill, *Earlier Letters*, 1812-1848, edited by Francis E. Mineka, *The Collected Works of John Stuart Mill*, volumes XII–XIII, Toronto, University of Toronto Press, London, Routledge and Kegan Paul, 1963, p. 211.

[3] See E. W. Strong, "William Whewell and John Stuart Mill: their controversy about scientific knowledge", *Journal of the History of Ideas*, vol. 16, no. 2, 1955, pp. 209–231.

[4] See James Passmore, *A Hundread Years of Philosophy*, second edition, Harmondsworth, Penguin Books, 1966, p. 13.

[5] Geoffrey Scarre, *Logic and Reality in the Philosophy of John Stuart Mill*, Dordrecht, Kluwer Academic Publisher, 1989, p. 3.

[6] Carl G. Hempel, Paul Oppenheim, "Studies in the logic of explanation", in Carl G. Hempel, *Aspects of Scientific Explanation and Other Essays in the Philosophy of Science*, New York, The Free Press, London, Collier-MacMillan, 1965, p. 251, footnote 7.

[7] John St. Mill, *A System of Logic Ratiocinative and Inductive, in Collected Works of John Stuart Mill*, volume VII, editor J. M. Robson, Toronto, University of Toronto Press, London, Routledge and Kegan Paul, 1974, Book III, Chapter XII, section 1, p. 464.

clear idea of what scientific explanation might be"[8], some philosophers agree that we are justified even go back to Plato and Aristotle in the case of a general theory of explanation[9], and others argue that Hume outlined a theory of causal explanation that was developed by Mill in a nomological-deductive way and this became the framework on which a tradition that leads directly to Hempel was founded[10]. Finally**,** some philosophers claim that in the decades immediately preceding the publication of Hempel and Oppenheim's paper, a lively debate on the topic of scientific explanation had taken shape and Mill's insights into explanation were among the basic elements of the background.[11] Others propose a unified history in which logical empiricism merges with the positivist tradition and goes back to Mill, and thus is seen as the origin of a tradition in the theory of explanation[12].

THE IDEA OF CAUSAL EXPLANATION OF FACTS

Let's return to Hempel's favourite passage from Mill's *System of Logic*, "An individual fact is said to be explained, by pointing out its cause, that is by stating the law or laws of causation, of which its production is an instance."[13] and conjoin it with an earlier passage in which Mill specifies how causal laws can be

[8] Wesley C. Salmon, *Four Decades of Scientific Explanation*, Pittsburgh, University of Pittsburgh Press, 1989, p. 10.

[9] See David-Hillel Ruben, *Explaining Explanations. Updated and Expanded Second Edition*, London and New York, Routledge, 2012, where a chapter is dedicated to each of the two ancient philosophers.

[10] For example, J. Kim underlines that the basic idea of this model goes back to John St. Mill (Jaegwon Kim, "Hempel, Explanation, Metaphysics", *Philosophical Studies: An International Journal for Philosophy in the Analytic Tradition*, Vol. 94, No. 1/2, 1999, p. 1).And Merrilee H. Salmon thinks that C. G. Hempel's work on explanation "lies squarely in the tradition of Mill" (Merrilee H. Salmon, "Explanation in the social sciences", in *Scientific Explanation, Minnesota Studies in the Philosophy of Science*, Volume 13, editors Wesley C. Salmon, Philip Kitcher, Minneapolis, University of Minnesota Press, 1989, p. 385).

[11] For example, Dewulf reveals that "the debates between Meyerson, Duhem, Cassirer, Mach, and Rickert are embedded within questions concerning the nature of scientific concepts, the standards of rationality, and the potential variability of those standards throughout the history of science" (Fons Dewulf, "Beyond Hempel: Reframing the Debate about Scientific Explanation", *Philosophy of Science*, 89, 2022, p. 600) and he warns us that "I do not claim that Hempel was the inventor of the deductive-nomological (DN) model of explanation, as one could claim that Popper or Mill had already written about explanation in a similar way." (Fons Dewulf, "Beyond Hempel: Reframing the Debate about Scientific Explanation", *Philosophy of Science*, 89, 2022, p. 587, footnote 1).

[12] Von Wright expressed this view: "Logical positivists and other analytical philosophers had already put forward views of explanation similar to those of Hempel. Essentially, all these views are variants of the explanation theory espoused by the classics of positivism, in particular by Mill." (Georg Henrik von Wright, *Explanation and Understanding*, London, Routlege and Kegan Paul, 1971, p. 27).

[13] John St. Mill, *A System of Logic Ratiocinative and Inductive*, in *Collected Works of John Stuart Mill*, volume VII, editor J.M. Robson, Toronto, University of Toronto Press, London, Routledge and Kegan Paul, 1974, Book III, Chapter XII, section 1, p. 464.

conceived as generalities derived by observing sequences of successive facts: "The law of causation... is but the familiar truth that invariability of succession is found by observation to obtain between every fact in nature and some other fact which has preceded it..."[14] Causal laws express uniformities of the succession of phenomena and their generality or factual universality is reducible to the assertion that a certain fact invariably occurs whenever certain circumstances are present and it does not occur when these circumstances are absent.

It is easy to notice that in Mill's proposal something survives from the idea of causal law proposed by Hume and from the debate opened by the latter regarding the understanding of the uniformity of nature. Hume's own clearest statement of his theory is given in *Enquiry*. His argument is developed in several steps. First, based on experience, we observe a series of phenomena that appear and are given together in our experience, but this does not mean that there is any relationship between them: "All events seem entirely loose and separate. One event follows another; but we never can observe any tie between them. They seem *conjoined*, but never *connected*"[15]. Secondly, the repeated association of two phenomena allows us to believe that things will be the same in the future: "But when one particular species of event has always, in all instances, been conjoined with another, we make no longer any scruple of foretelling one upon the appearance of the other. (…) We then call the one object, *Cause*, the other, *Effect*"[16] Thirdly, based on our experience of these successions of events, we may have the idea of uniformity of nature and, moreover, the idea of a necessary connexion between the two:

> Similar objects are always conjoined with similar. Of this we have experience. Suitably to this experience, therefore, we may define a cause to be *an object, followed by another, and where all the objects similar to the first are followed by objects similar to the second*. Or, in other words, *where, if the first object had not been, the second never had existed*. The appearance of a cause always conveys the mind, by a customary transition, to the idea of the effect. Of this also we have experience. We may, therefore, suitably to this experience, form another definition of cause, and call it, *an object followed by another, and whose appearance always conveys the thought to that other*[17].

As a result, "We may consider the relation of cause and effect in either of these two lights; but beyond these, we have no idea of it"[18].

[14] John St. Mill, *A System of Logic Ratiocinative and Inductive*, in *Collected Works of John Stuart Mill*, volume VII, editor J. M. Robson, Toronto, University of Toronto Press, London, Routledge and Kegan Paul, 1974, Book III, Chapter V, section 2, p. 327.

[15] David Hume, *An Enquiry Concerning Human Understanding*, edited by Eric Steinberg, Indianapolis, Cambridge, Hackett Publishing company, 1993, p. 49.

[16] *Ibidem*, p. 50.

[17] *Ibidem*, p. 51.

[18] *Ibidem*, pp. 51–52.

The standard empiricist interpretation[19] of this passage that dominated the nineteenth century thought was that causation has two aspects, one objective, as a constant succession of events in the world, the other subjective, as a constant association of ideas in our mind. All we know by experience is nothing but these successions and we may associate objects with impressions, impressions with ideas and ideas with ideas creating complex ideas. Hume analysed this subjective mechanism in the *Treatise* where he attributed the necessary connection exclusively to the mind and identified it with the constant association of ideas:

> Upon the whole necessity is something that exists in the mind, not in objects; nor is it possible for us ever to form the most distant idea of it, considered as a quality in bodies. Either we have no idea of necessity, or necessity is nothing but that determination of the thought to pass from causes to effects, and from effects to causes, according to their experienced union[20].

The consequences of this vision on the idea of necessary connexion are clearly derived by Hume: first, that the simple view of any two objects, however related, can never give us any idea of a connexion between them; second, that this idea arises from their repetition; third, that the repetition doesn't cause anything in the objects, but it has an influence on the mind; fourth, that necessity is a quality of our ideas, not of external objects, and it is felt as such.

Mill's view, initially stated in *A system of logic*, Book III, the chapter "Of the Law of Universal Causation", is heavily indebted to Hume, but with an accent on the objective side of causality. Mill's discourse is about facts and their positions as antecedent and consequent in a causal relation, and the universality of causation is objectively related with the factual connexion between the antecedent and the consequent:

> To certain facts, certain facts always do, and, as we believe, will continue to succeed. The invariable antecedent is termed the cause; the invariable consequent, the effect. And the universality of the law of causation consists in this, that every consequent is connected in this manner with some particular antecedent, or set of antecedents[21].

But Mill immediately is forced to change this view taken for granted from Hume because he also has to take into account an objection proposed by Thomas Reid against this definition of causality: since the phenomena of day and night have invariably succeeded one another from the beginning of the world, and they

[19] See James B. Peterson, "The Empirical Theory of Causation", *The Philosophical Review*, Vol. 7, No. 1, 1898, pp. 43–61.

[20] David Hume, *A Treatise of Human Nature*, edited by Ernest C. Mosner, Harmondsworth, Penguin Books, Book I, Part III, section XIV, p. 216.

[21] John St. Mill, *A System of Logic Ratiocinative and Inductive*, in *Collected Works of John Stuart Mill*, volume VII, editor J. M. Robson, Toronto, University of Toronto Press, London, Routledge and Kegan Paul, 1974, Book III, Chapter V, section 2, p. 327.

are given invariably in our experience, we have to conclude, according to this doctrine of causality, that night must be the cause of day and day the cause of night[22]. Mill notes that this doctrine implies that the meaning of the word "cause" supposes not only that until now the antecedent always *has* been followed by the consequent, but much more, namely, that as long as the present constitution of the world will remain the same, it always *will* be so[23]. Mill agreed that the objection urged by Reid about the case of day and night succession means that the relation between night and day isn't a causal one. Indeed, "we do not believe that night will be followed by day under all imaginable circumstances, but only that it will be so *provided* the sun rises above the horizon"[24].

Reid's objection is met by Mill with the argument that in the case of real causation the sequence of events is not only invariable, but also unconditional:

> This is what writers mean when they say that the notion of cause involves the idea of necessity. If there be any meaning which confessedly belongs to the term necessity, it is *unconditionalness*. That which is necessary, that which *must* be, means that which will be, whatever supposition we may make in regard to all other things. The succession of day and night evidently is not necessary in this sense. It is conditional on the occurrence of other antecedents[25].

Therefore, concludes Mill, we may define "the cause of a phenomenon to be the antecedents, or the concurrence of antecedents, on which it is invariably and *unconditionally* consequent"[26].

A DEDUCTIVE EXPLANATION OF LAWS

But Mill's vision of the idea of necessary connexion is not limited only to the causal explanation of the facts, but also he considers the explanation of causal laws with the help of other more complex and universal laws: „A law or uniformity of nature is said to be explained, when another law or laws are pointed out, of which that law is but a case, and from which it could be deduced."[27] Therefore, it is

[22] See Thomas Reid, *Essay on the Intellectual Powers of Man*, in *The Works of Thomas Reid*, edited by William Hamilton, Edinburgh, Maclachlan and Stewart, 1846, Essay II, Chapter IV, p. 253.

[23] Mill adds in a footnote that the idea of a constitution of the world is related with that of the ultimate laws of nature, even if it isn't clear what they mean, but it is rationally obvious that the ultimate laws have to be distinguished from the derivative laws. For example, the diurnal revolution of the Earth isn't a part of the constitution of the world because it can be determined or altered by natural causes. (John St. Mill, *A System of Logic Ratiocinative and Inductive*, in *Collected Works of John Stuart Mill*, volume VII, editor J. M. Robson, Toronto, University of Toronto Press, London, Routledge and Kegan Paul, 1974, Book III, Chapter V, section 6, p. 338).

[24] *Ibidem*, pp. 338–339.

[25] *Ibidem*, p. 339.

[26] *Ibidem*, p. 340.

[27] *Ibidem*, p. 464.

obvious that according to this distinction between explanation of facts and explanation of laws, Mill distinguishes between singular facts, explained by causal laws, and "universally general facts," explained by more general laws whose logical form is also that of a conditional statement, namely, that if all the objects have the property P, then they have the property Q. A universally general fact has the form of universally quantified sentences.

I think that this distinction between singular facts and universal facts, as conceived by Mill, is not problematic since the whole problem can be reduced to a trivial logical exercise of quantification. However, difficulties arise when we try to elucidate the explanatory relationships between these different types of laws, more precisely, when we try to show how one law can be explained by another law. Mill insists that we distinguish between the common meaning and the scientific meaning of 'explanation.' According to the common meaning, "the explanation may substitute a mystery which has become familiar, and has grown to seem not mysterious, for one which is still strange"[28]. By contrast, a scientific explanation "resolves a phenomenon with which we are familiar into one of which we previously knew little or nothing"[29], by pointing deductively to some phenomena as exemplification, or to some conditions, or to some causal laws, all of them initially unknown but determined deductively inside the system of science. For example, the movement of heavenly bodies and the fall of terrestrial bodies were thus explained by the theory of gravity.

Therefore, our main epistemological task, if we are interested in understanding how new knowledge is produced and justified, becomes that of disclosing the mechanisms of scientific explanation. Mill is aware that this is the turning point of his theory and offers a very accurate analysis, distinguishing between three modes of explanations of the laws of nature.

The first mode consists in a break-down analysis through which a complex law of a complex effect "is resolved into the separate laws of the causes which contribute to it."[30] For example, the law of the motion of a planet is resolved into two laws of the two forces, the rectilinear force and the gravitational force. The first is the so-called "acquired" force which tend to produce a uniform motion on the tangent, and the second is the centripetal force which tends to produce an accelerated motion towards the sun. But in the case of real movements, as would be the case of heavenly bodies, it is necessary to take into account other agents, powers and circumstances of time and place so that the result of the deduction is correct. In other words, using Mill's generalizing terminology, the first mode of explaining a law of nature amounts to this methodological rule: "the law of an effect of combined causes is resolved into the separate laws of the causes, together with the fact of their combination"[31].

[28] *Ibidem*, pp. 471–472.
[29] *Ibidem*, p. 472.
[30] *Ibidem*, p. 464.
[31] *Ibidem*, p. 471.

The second mode of explaining a law is "by the deduction of an intermediate link in the sequence"[32] between what seems to be the cause and what is supposed to be its effect. The intermediate link, let's name it *B*, is a fact caused by the antecedent *A* and it (*B*) is the cause of the consequent *C*, so that the first assigned cause *A* is only a remote cause of *C*, and the cause discovered later, the intermediate link *B*, becomes the direct cause of *C*. For example, touching an object is only the remote cause of a sensation, because the real cause of a sensation is a change in the state of our neural network. Therefore, the sequence of an object and a sensation is explained by its division in other two sequences, each of the two with its own causal laws. This means that the law associated with the sequence from *A* to *C* isn't an ultimate law and also that it is less general than the laws associated to the sequences from *A* to *B* and from *B* to *C*. These last two laws explain the first law and they are logically and epistemologically more general than the first because they could be extended to more cases than the first law, without falling under the limitations that experience would fix in the case of the first. In other words, using Mill's generalizing terminology, the second first mode of explaining a law of nature amounts to this methodological rule: "the law which connects any two links, not proximate, in a chain of causation, is resolved into the laws which connect each with the intermediate links"[33].

The third mode of explanation is "the *subsumption* of less general laws under a more general one", where by "subsumption" we mean nothing but "the gathering up of several laws into one more general law which includes them all"[34]. The best example is that of Newton's unification of the forces that explain the fall of bodies near the surface of the earth and the forces that explain the orbital movement of the planets in the solar system under the general law of gravity. We recognize in this third way one of the most discussed themes in the philosophy of science regarding intertheoretical relations and the possibility of theoretical unification. The methodological rule is the deductive unification of different theories into a more general one which has more explanatory power than the previous theories and it is also able to make predictions about some new facts. Mill becomes all the more remarkable as we find that he has not only anticipated such debates, but also put them in a correct form, broadly valid even today.

The first two modes are cases of resolving one law into one or more, while the third mode is a case of resolving two or more laws into one. In the third mode we have to follow this methodological rule: "after the law has been shown to hold good in several different classes of cases, we decide that what is true in each of these classes of cases, is true under some more general supposition, consisting of what all those classes of cases have in common"[35]. Moreover, it is very important

[32] *Ibidem*, p. 465.
[33] *Ibidem*, p. 471.
[34] *Ibidem*, p. 469.
[35] *Ibidem*, p. 471.

to notice that Mill's reasoning: "since we need not suppose the result to be extended by way of inference to any new class of cases, different from those by the comparison of which it was engendered"[36], in the third mode of explanation the logical procedure is deductive so that it doesn't involve any of the uncertainties traditionally associated with induction.

In all the three modes the laws are resolved into more general laws, and in the first two modes the laws are also resolved into more certain laws. As a result, in the case of each of the three modes of explanatory reduction of a law to one or more general laws, we have the epistemic right to claim that "they are more nearly unconditional; they are defeated by fewer contingencies; they are a nearer approach to the universal truth of nature"[37]. This means only that, following the methodological rules stated above, we can advance towards more and more certain laws, yet always the laws we know – even if they prove to be true – will be true only under certain conditions, or for a certain field of facts, or in relation to certain simpler laws, and not universally true.

All the more surprising for the supporters of a strict empiricist-inductivist traditional interpretation of Mill's theory of scientific knowledge, it must be emphasized that he is very explicit in supporting an understanding of science as a deductive system. Mill argues that by all these three modes of explaining natural laws "the range of deductive science is extended"[38]. The explaining laws are always more general than the laws to be explained, more accurate and closer to the universal truth, but this ultimate truth will remain unknown. In any event, to complete the epistemological agenda, Mill surprises again by formulating the hypothesis of the possibility of a generalized unifying explanation based on a minimal set of principles, similar to a unified theory of fundamental forces or, more than that, a Theory of Everything: "What are the fewest assumptions, which being granted, the order of nature as it exists would be the result? What are the fewest general propositions from which all the uniformities existing in nature could be deduced?"[39].

According to Mill, the power of explanation is always limited. There are inexplicable singular facts and inexplicable universally general facts or general laws. Undoubtedly, the ultimate laws have no further explanation and „every resolution of a derivative law into more general laws brings us near to them"[40]. But also there are some inexplicable singular facts concerning the distribution of the primeval causes or natural agents through the universe. For example, even if the ultimate causal laws are the same, the derivative laws will be completely different if at some moment the proportions of the co-existing causes were different. If the sun had a different mass and its force of attraction were different, then "the derivative laws of the heavenly motions might have been quite different from what they are"[41].

[36] *Idem.*
[37] *Ibidem*, pp. 467–468.
[38] *Ibidem*, p. 471.
[39] *Ibidem*, p. 472.
[40] *Ibidem*, p. 484.
[41] *Ibidem*, p. 517.

Mill also proposes a deductive epistemic version of a symmetry thesis between explanation and prediction. Starting from the multitude of deductive relationships, from a system of law statements that correlate causes and effects and from the deductive possibilities we have inside such a system, Mill distinguishes between two questions: „Given a certain combination of cause, what effect will follow? and What combination of causes, if it existed, would produce a given effect?"[42] The answers to the two questions are different: in the first case we have to determine the effect that will be expected in some complex circumstances which are known by us, while in the second case we discover and reveal, according to the laws and the given effect, both known by us, under what antecedent or causal condition the effect was produced. This symmetry is considered by Mill as a constitutive deductive property of the whole system and it has a key epistemological role in our progress from what we know to what is unknown to us. The extension of science as a deductive system is based on this symmetry: "the same deductive process which proves a law or fact of causation if unknown, serves to explain it when known"[43].

Therefore, taking into account all that has been asserted so far, the conclusion is that we find in Mill not only a sketch of Hempel's model, but a fine articulation down to the level of details, with the exception of the formal aspects. It is obvious that many, but not all, of Mill's proposals conform to Hempel's model, and that the general framework is the same, guided by the principle that all the explanations are a subset of the set of valid arguments.

Far from being a simple follower of the inductive methods proposed by Bacon, as, surprisingly, he was unfairly and superficially considered by the philosophical tradition, Mill is aware of the fact that he is making a radical change in the debate about the scientific method, but in a direction contrary to Bacon: "A revolution is peaceably and progressively effecting itself in philosophy, the reverse of that to which Bacon has attached his name"[44]. Mill notes "the tendency of all the sciences to become deductive"[45]**,** so that even if it is correct that Bacon "changed the method of the sciences from deductive to experimental"[46], is the method has now reverted from experimental to deductive, but on another level, where the deductive method itself is radically changed. If the deductive method abolished by Bacon was nothing but the Aristotelian syllogistic elaborated by scholasticism, the new deductive method involves advancing under the control of experience by following strict canons of verification. All these differences between the scientific method described by Bacon and the deductive method proposed by Mill are a result and an expression of scientific progress. Mill endorses his

[42] *Ibidem*, p.460.
[43] *Ibidem*, p. 471.
[44] *Ibidem*, p. 482.
[45] *Ibidem*, p. 481.
[46] *Ibidem*, p. 482.

deductive method and fixes its origin in modern science: "Between the primitive method of Deduction and that which I have attempted to characterize, there is all the difference which exists between the Aristotelian physics and the Newtonian theory of the heavens"[47].

MILL'S ACCOUNT OF DEDUCTION

So, as I have said in detail above, Mill proposed a deductive approach to scientific explanation and developed a model of scientific theory that was very close to the one developed later by Popper and Hempel and which is basic for all the debates in the contemporary philosophy of science. Independently of his theory of explanation through laws, Mill also proposed a novel approach to deduction from a logical perspective. I will further go into the details of this approach in order to note its consequences for the deductive model of explanation.

In this regard, the statement for which Mill is well known (and it is almost a trademark of his thought) is his criticism of syllogistic reasoning as the main example of deductive reasoning. Mill claims that a deductive inference is circular: „It must be granted that in every syllogism considered as an argument to prove the conclusion, there is a *petitio principi*."[48] When we conclude that "Socrates is mortal" based on premises that "All men are mortal" and "Socrates is a man", the conclusion of our syllogism is presupposed from the beginning in the more general assumption "All men are mortal", a premise of our reasoning, because we cannot assert the mortality of all men unless we are already certain about the mortality of every man. If we aren't sure about the mortality of Socrates, then the premise "All men are mortal" is exposed to uncertainty. Mill concludes that "no reasoning from generals to particulars can, as such, prove anything, since from a general principle we cannot infer any particulars, but those which the principle itself assumes as known"[49].

Mill's treatment of deduction can only be understood if we take into account the epistemological framework in which the problem of deduction is formulated starting from the epistemological task of identifying the possibilities of producing new knowledge. Therefore, Mill's problem is an epistemological one: how, in principle, can deductive and inductive modes of inference produce new knowledge? Mill's answer is given from an empiricist standpoint:

> All knowledge consists of generalizations based on experience (...) There is no a priori knowledge, no truth that can be known by the inner light of our mind and founded on intuitive evidence. The mind's sensation and awareness

[47] *Idem*.
[48] *Ibidem*, p. 184.
[49] *Idem.*

> of its own acts are not only the exclusive sources, but the only materials of our knowledge.[50]

As a consequence, if the only source of knowledge is experience, then a deductive inference has to be founded upon a special kind of non-deductive inference because at least one of the premises has to be obtained non-deductively if our goal is to produce new knowledge. Mill's fundamental commitment is very important: we cannot discover anything new by deduction. Our epistemic goal is to enlarge our knowledge, to produce new knowledge, and deduction is of no use to us in this regard.

Moreover, if we set aside this epistemological framework, and look at the problem from a logical standpoint, we immediately notice that Mill suggests a puzzling "reduction" of deductive reasoning, including syllogisms, to inductive reasoning. He surprisingly states that all genuine reasoning is inductive reasoning and seems to try to argue that all inductive reasoning is nothing but an inference from particulars to particulars: "General propositions are a record from such inferences from particulars to particulars, and the rules of the syllogism are rules for the interpretation of the record"[51]. When we conclude that "All men are mortal" after we observed some people who died and received testimonies about the fact that people die, this means that our own former experience is the proof of this generalization. Therefore, the logical inference of a universal generalization from particular cases is nothing but the recognition of the logical equivalence of a universally quantified proposition with a conjunction of particular propositions. If we adopt this interpretation of Mill's way of thinking, then the problem is solved: "if Mill believed that general propositions were themselves conjunctions of particular propositions, his claim that all reasoning is from particulars to particulars immediately becomes less mysterious"[52].

As a result, a correct approach to deduction from Mill's perspective must be accompanied by fixing its place in the knowledge process and understanding the balance between inductive and deductive reasoning. First of all, according to Mill's empiricist principle, we are able to know the world as it is given to us in sensations and we can perceive uniformities in the sequences of phenomena. Mill distinguishes between uniformities of coexistent phenomena and uniformities of successive phenomena: „The order of the occurrence of the phenomena in time is either successive or simultaneous; the uniformities, therefore, which obtain in their

[50] John St. Mill, *Essays on Ethics, Religion and Society*, edited by. J.M. Robson, introduction by F.E.L. Priestley and D.P. Dryer, *Collected Works of John Stuart Mill*, volume X, Toronto, University of Toronto Press, London, Routledge and Kegan Paul, 1969, p. 125.

[51] John St. Mill, *A System of Logic Ratiocinative and Inductive*, in *Collected Works of John Stuart Mill*, volume VII, editor J.M. Robson, Toronto, University of Toronto Press, London, Routledge and Kegan Paul, 1974, Book II, Chapter III, section 4, p. 193.

[52] Wendy Donner, Richard Fumerton, *Mill*, Oxford, Wiley-Blackwell, 2009, p. 164.

occurrence, are either uniformities of succession or of co-existence"[53]. From the set of uniformities Mill extracts the subset of causal uniformities. These causal uniformities of succession are invariable and unconditional regularities of experience and we may elucidate them using the famous four inductive methods: the method of agreement, the method of difference, the method of residues, and the method of concomitant variations. Mill develops the theory about these four methods based on the deterministic assumption that there is a cause for everything that happens and that if a cause is given, an effect invariably follows. This commitment to deterministic causation is related by Mill to the idea of epistemic certainty using the power of deduction. The explanation based on causal laws is nothing but deductive reasoning. Finally, for Mill, the deductive method thus becomes a source of knowledge, understood as "the mode of investigation which, from the proved inapplicability of direct methods of observation and experiment, remains to us as the main source of the knowledge we possess or can acquire respecting the conditions, and laws of recurrence, of the more complex phenomena"[54].

But how does the deductive method work so as to be in agreement with the principles of an empiricist epistemology? Mill considers that the inductiv-deductive method consists of three successive and distinct operations – direct induction, ratiocination, and verification – that maintain the relationship with experience and put the deductive derivatives under its control.

The first stage, "ascertainment of the laws of the separate causes by direct induction"[55] is an inductive operation generally based on the four methods of induction. We may consider the exception of those cases where induction is supplied by an a priori deduction, but even in these cases the premises must have been also inductively derived. For example, we discover by induction starting from instances, the law that any body in rectilinear and uniform motion tends to maintain its state of motion as long as no other forces act. Moreover, once we have accepted this law, we can anticipate that a body will follow a curved trajectory under the influence of forces of a certain kind.

The second step, "ratiocination from the simple laws of the complex cases,"[56] is a process of calculation, based on numerical laws and mathematics, by which we determine, according to the laws, the effects which will be produced by a combination of conditions or causes. For example, we may determine the motion of a projectile if we know the causes which affect its velocity, among them the force of the explosion of the gunpowder, the density of the air, or the angle of elevation.

[53] John St. Mill, *A System of Logic Ratiocinative and Inductive*, in *Collected Works of John Stuart Mill*, volume VII, editor J.M. Robson, Toronto, University of Toronto Press, London, Routledge and Kegan Paul, 1974, Book III, Chapter XXII, section 1, p. 578.

[54] John St. Mill, *A System of Logic Ratiocinative and Inductive*, in *Collected Works of John Stuart Mill*, volume VII, editor J.M. Robson, Toronto, University of Toronto Press, London, Routledge and Kegan Paul, 1974, Book III, Chapter XI, section 1, p. 454.

[55] *Idem*.

[56] *Ibidem*, p. 458.

The third stage, "verification by specific experience,"[57] is a process of deductive derivation of some empirical consequences from the already accepted laws conjoined with some observed conditions. For example, in the case of the movements of the heavenly bodies, we can verify the correctness of Kepler's laws by seeing to what extent they describe the movements we recorded observationally. Moreover, Mill adds, we can explain facts that have not yet been observed or thought of on the basis of laws, and the verification will take place later: "any law of nature is deemed to have gained in point of certainty, by being found to explain some complex case which had not previously been thought of in connexion with it"[58].

INSTEAD OF CONCLUSION: THE FINAL CUT

Undoubtedly, Mill holds a deductive theory of explanation, but he also claims that deduction cannot advance our knowledge. How shall we understand this epistemic downgrading of deduction? Is there a formal contradiction between Mill's deductive theory of explanation and the reductive account of deductive inference? Are the deductive theory of explanation and Mill's criticism of deductive arguments as *petitio principi* compatible? These were the questions that guided my research.

This detailed search proposed above was supported by my reasonable belief that the deductive theory of explanation and the reductive account of deduction may work together if we take into account the way in which Mill develops his own theories, apparently eclectic, but always faithful to his theoretical principles, above all to a consistent and consequent empiricism that we find in any philosophical enterprise he undertakes. The conjunction between the two views is apparently strange and unexpected and it had to be explained[59]. This was the reason why I focused carefully on some philosophical trifles that I highlighted with the help of some quotations from Mill's work. The last one closes the story:

> To entitle a hypothesis to be received as one of the truths of nature, and not as a mere technical help to the human faculties, it must be capable of being tested by the cannons of legitimate induction, and must actually have been submitted to the test. When this shall have been done, and done successfully, premise will have been obtained from which all the other propositions of the science will thenceforth be presented as conclusions, and the science will, by means of a new and unexpected Induction, be rendered Deductive[60].

[57] *Ibidem*, p. 460.
[58] *Ibidem*, p. 462.
[59] A similar puzzling challange is noted and explored by Ryan. See Alan Ryan, *The Philosophy of John Stuart Mill*, London, Macmillan, 1971, pp. 3–20.
[60] *Ibidem*, p. 483.