[Forthcoming in
Christian Damböck & Georg Schiemer (eds.). *Rudolf Carnap Handbuch*. J.B. Metzler Verlag, 2024]

Adam Tamas Tuboly
(a) MTA Lendület Values and Science Research Group, Institute of Philosophy, Research Centre for the Humanities
(b) Institute for Transdisciplinary Discoveries, Medical School, University of Pécs
tubolyadamtamas@gmail.com

An Introduction to Philosophy of Science

While in the English-speaking world, Carnap is known primarily as a philosopher of science who defined the major problems, concepts, and method of the field, he published only one work in English about this subject. It came out in 1966 under the title *Philosophical Foundations of Physics: An Introduction to the Philosophy of Science* by Basic Books (New York). The book was reprinted as a cheaper paperback edition in 1974, now with the previous subtitle – *An Introduction to Philosophy of Science* – as its main title (a move initiated by Wesley C. Salmon's (1967) review), and an inexpensive Dover edition was issued later in 1995. It is decidedly one of Carnap's most sold books, used around the globe in many classrooms as a work of reference.

Context

Carnap's book is interesting and important for various reasons. It was published four years after Thomas Kuhn's seminal *Structure of Scientific Revolutions*, and thus at a time when logical positivism and even Carnap were arguably past their peak. Many people sought to dethrone both the scholar and his school, among them sociologists of science, historians of science, pragmatists, and even anarchists such as Paul Feyerabend (see Chapter 32 by Kuby).

During the 1940s and 1950s, there wasn't any major, detailed, and comprehensive textbook on the philosophy of science. In the 1940s and 1950s, the collections brought out by Herbert Feigl and May Brodbeck and by Philipp P. Wiener (both titled *Readings in the Philosophy of Science*) were taught and read by many. In 1957, Philipp Frank published his major book, *Philosophy of Science: The Link between Philosophy and Science*, but it was much too long to become a standard textbook and too old-fashioned for many because of its treatment of metaphysics, worldview, and sociological approach to theory formation. In the 1960s, Ernest Nagel finally (1961) published his long-waited book on *The Structure of Science*, and Arthur Pap (1962) his *Philosophy of Science*. The latter seemingly went unnoticed, while the former was a 600-page monster full of detailed arguments that was also overshadowed by the unexpected success of Kuhn's text (though it was read and taught for decades).

Carnap's book was different, however, and given all the discrepancies plaguing the available alternatives, it enabled him to hit the market again. IPoS is, in fact, an edited version of Carnap's own lectures on philosophy of science that he delivered first in Chicago during the 1930s and 1940s, and later at UCLA in the 1958/59 winter term. It was Martin Gardner, first his student and later a renowned science writer, who suggested to Carnap that his wife Ina should tape-record the seminar, so that Gardner could then edit the material into a coherent volume and publish it as a classroom textbook. Carnap liked the idea. The book is based on his lectures, and thus its language is much lighter than his posthumously published *Entropy* book, for example. As Wesley Salmon (1967, 1235) wrote in his review, "it is a sustained exhibition of Carnap's talent as an inspired teacher who can make the most abstract technicalities intelligible to the uninitiated." Carnap was praised as a teacher wherever he went, and his book was welcomed as an important gesture, a "well-constructed introduction to his field." As Salmon emphasized, "Carnap constantly had his finger upon the essentials." But what were these essentials?

The Book's Structure and Principal Topics

IPoS is made up of five longer parts, with a shorter, often criticized sixth section, "Beyond Determinism," referred to by one reviewer as "hardly more than an afterthought" (Workman 1967, 367)

The book starts with the hot topics of the day: explanation and laws. Carnap follows in C.G. Hempel's footsteps and argues that an explanation is a well-structured argument (for all *x*, if P*x* then Q*x*; P*a*; therefore Q*a*), consisting of a premise featuring a general statement about laws, a "universal conditional statement" (Carnap also recognized and admitted the existence of statistical laws), and also a fact. "Facts" are just particular events (for instance, sending an electronic current through a wire coil with an iron body inside it and then discovering that the iron body has become magnetic). An explanation is an answer to a "why" question – it does not reveal any hidden metaphysical factors in nature, but simply gives as *reasons* laws under which a particular event can be subordinate. "You cannot give an explanation without also giving a law" (p. 14), which is an important insight that many philosophers lacked, according to Carnap, for whom a law is "simply referring to a description of an observed regularity" (p. 207).

After explanation, the other side of the coin is prediction. Predictions have the same form as explanations (for all *x*, if P*x* then Q*x*; P*a*; therefore Q*a*), and Carnap makes a similar argument. Once we have a law, and we know a certain fact, we can then make conclusions about a new fact and predict its occurrence. In this respect, Carnap also includes the prediction of past events. Prediction, however, is of utmost importance: Even turning a doorknob involves prediction (knowing what happens in such situations), though we obviously do not reflect on it. "Prediction is involved in every act of human behavior that involves deliberate choice. Without it, both science and everyday life would be impossible" (p. 18).

In several chapters, Carnap discusses the relation of induction (the path from facts to laws, one of the most important problems of philosophy of science, as he says on p. 5) to statistical probability and logical probability, one of his major findings from the 1940s, namely that one should always categorize and explicate the different meanings of "probability." His most interesting aside, however, is that one cannot expect to arrive at a final algorithmic procedure based on fixed rules, and thereby "to devise a new system of theoretical concepts, and with its help a theory. Creative ingenuity is required" (p. 33). He says the same again in the context of theoretical laws (contra empirical laws, p. 230) – and interestingly, the ingenuity factor and the contingent aspect of being human resurface in the chapter on "experiments," where Carnap described the basics of experimentation, with a focus on how to choose the right variables and what to omit. He concludes that, "cultural beliefs thus sometimes influence what is considered relevant" (p. 45), though a general "common-sense guess" would suffice in most cases.

The next section, entitled "Measurement and Quantitative Language," deals with the process of how to measure experiments. This is the most extensive part of the book, composed of eight chapters in which Carnap discusses the different concepts of science (classificatory, comparative, and quantitative, emphasizing here a restricted form of conventionalism, pp. 59, 69), the act of measurement, magnitudes, time, and length. Carnap also confronts the reader with the possible merits of quantitative language and the quantitative method (he justifies these questions by noting that it is *us human beings* who force numbers on nature, and not vice versa): This aspect is partially ideological – having a smaller and simpler vocabulary – and partially methodological, since it enables us to formulate more exact laws. However, Carnap again notes that the alternative approach based on qualities and intuition (attributed to Goethe and his scientific work) has its own advantages "for the discovery of new facts and the development of new theories, especially in relatively new fields of knowledge" (p. 111). Most surprisingly, Carnap closes this part with a chapter on "the magic view of language," according to which there should be a natural relation between words and their meanings. Because of this magical relation, people tend to favor qualitative language exclusively and consider the quantitative approach a form of degeneration by which we lose something essential in our understanding of the world. Carnap quotes extensively from a contemporary book that advocated a similar view and argues that quantitative and qualitative language should be *complementary*, representing different approaches, not the only valid language on the market. Tolerance thus prevailed (see Chapter 19, Chapter 65 by Creath, and Chapter 76 by Kouri).

An entire section of the book is devoted only to the question of space, the topic of Carnap's dissertation and first publications (see Chapter 34 by Wagner). Its importance is legitimated by the fact that the analysis of space reveals the basic structure of modern physics; moreover, mathematical and physical geometry are two paradigms of knowledge production: "the aprioristic and the empirical." Carnap reconstructs the discovery and meaning of Euclidean and non-Euclidean geometries, leading up to Poincaré's conventionalism, which he stratifies further by positing that even two empirically equivalent theories may lead to different predictions, ending up in "essentially different physical theories" (p. 150). Carnap then discusses the special theory of relativity and addresses some counterarguments that are based on the difficulties of visualizing the new physics. He considers these arguments invalid and shows how such contingent issues are (necessarily) unable to falsify the theoretical business. This part ends with an interesting discussion on Kant's synthetic *a priori*, not the hottest topic within philosophy of science at the time, but one that was essential in the 1910s and 1920s during Carnap's formative years (p. 180). Carnap naturally rejects Kant's approach to synthetic *a priori* (without any hint towards what became known as the new *relative a priori*) and points out, á la Einstein, that "Mathematical geometry is a priori. Physical geometry is synthetic. No geometry is both" (p. 183).

Causality and determinism make up another big portion of the book. In Part IV, Carnap argues that as causality plays an eminent role both in everyday life and the sciences, analyzing this concept is "one of the most important tasks of philosophy of science" (p. 189). He does not dismiss the *notion* of causality, but instead aims to undertake a sort of housecleaning, a purification, removing all animistic, humanistic, non-scientific elements. After providing many everyday examples, Carnap concludes that causal relations in principle mean predictability, i.e., in a situation, when we are looking for causes, it would be possible, if we knew all the laws of nature, the particular facts, "to predict the event before it happened." But Carnap displays some unease on this point; given the continuous progress of science, our knowledge undergoes various revisions and extensions, and thus we never know *all* the relevant laws, not even in principle – and without them, causal relations are not obtainable. Nonetheless, Carnap argues, perhaps a certain *dependence* could be formulated, meaning that if this and that were known, this and that could be predicted. And with this dependence, necessity raises its ugly head, which is problematic for an empiricist.

Adding the phrase "and this holds with necessity" is what distinguishes two physicists, one believing in necessary connections, the other not. But their physical work is not affected by this belief: both can make the very same predictions, and both will check the results of their predictions in a similar manner. Saying that event *E* will happen tomorrow, and that event *E* will happen tomorrow necessarily, does not influence the *actual outcome* and its control. With regard to their cognitive content (which is what matters for science), modalities add nothing, "because the cognitive meaning of a law lies in its potentialities for prediction" (p. 201). Thus, the modal character of causality is placed under the *logical* category: truth and consequences. A statement is causally true, says Carnap, if it is a logical consequence of the class of basic laws, which are statements with nomic form that are true (they are not restricted, for example, to space and time, like those of economics and history). But in the 1950s, when Carnap delivered his lectures, causal modalities, the scientific-philosophical rendering of the old metaphysical problem about the causal structure of the world, was relatively new, and people were only starting to inquire into counterfactual conditionals and similar issues (Reichenbach had just published his treatise on the modalities and causalities).

Causal structures led Carnap to determinism; given a complete description of the entire state of the world at one instant in time, any event in the past or future can be calculated with the help of laws (p. 217). He notes that according to quantum mechanics, this strong form of determinism (established by Laplace) does not hold anymore, but in his opinion none of this has any bearing on the question of free will. Contrary to Reichenbach, who thinks that speaking of free will, choice or rational deliberation would be meaningless if determinism were true, Carnap carves out a place for this whole issue within the separation of predictability and compulsion. The former relates to explanation and causality, and thus to determinism, while the latter belongs to certain positive and negative restrictions and forces. In the context of a prisoner's escape, a closed door is a form of compulsion, as is grabbing someone's hand to pull the trigger of a gun and shoot another person against their will, but Carnap includes here "all sorts of nonphysical means, such as by threatening terrible consequences" (p. 219). Acting in accordance with regularities and preferences, something a Reichenbach-type determinist would count as a *determined non-free act*, is not a form of compulsion for Carnap, but merely behavior that arises from one's own character; thus, he differentiates between compulsion and determinism, and between randomness and freedom (cf. Creath 2023 and Chapter 26 by Padovani). In the end, Carnap concludes that whatever may be the case scientifically speaking, the indeterminacy of the quantum level does not have any bearing on such complex systems as stones and humans, while even in the deterministic world of classical physics, our "limitation of knowledge" has very direct consequences on our actions and morals.

The book's most influential part is definitely the fifth, which focuses on "theoretical laws and theoretical concepts." As most of its findings and theses are discussed in detail elsewhere in this book (see Chapters 56 and 59 by Andreas and Chapter 61 by Patton, for instance), it suffices to note that Carnap draws various continuities: the continuity, for example, between what is observable (philosophers working with a narrow notion of direct senses, while physicists accept more abstract, but still measurable issues), and between the observable and the theoretical, connected by correspondence rules. His most important addition to the literature is, beyond doubt, his treatment of the Ramsey sentence. In a Ramsey sentence, all the perplexing theoretical terms are eliminated in favor of variables, bound by an existential quantifier, that are characterized by their properties. Thus, the word "electron" does not appear in a description of a theory, but is replaced by a variable that has all the properties of an electron. Although something may seem to be lost in the process, a Ramsey sentence depicts all the observational content of a theory, and according to Carnap, it was "Ramsey's great insight that this observational content is all that is needed for the theory to function as theory, that is, to explain facts and predict new ones" (p. 254).

Although Carnap was writing years after Quine's famous critique of the analytic-synthetic distinction, he still adheres to this "sharp distinction" (p. 257), while adding that natural languages are too complicated to formulate unambiguous analytic sentences (a point for Quine); but by introducing meaning postulates (which he now calls "A" postulates), Carnap defines certain analytic statements, restricted somewhat to non-natural languages, though analyticity in the theoretical language merited a chapter of its own because of its difficulties.

The book ends with a short discussion of quantum issues (called "Beyond determinism"). Here, Carnap treats in some detail what he calls "statistical laws," and returns to the question of determinism-indeterminism, focusing now on the latter, through Heisenberg's uncertainty relation. While presenting several suggestions to meet the challenges to classical forms raised by quantum mechanics, he addresses both Martin Strauss' rejection of the classical logical connectives on account of their non-conformability, and Reichenbach's many-valued logics – for Carnap, this is too much of a violation of our normal logics. Though he accepts both as permissible moves in line with the principle of tolerance, from a practical point of view, he considers them – at that particular moment of historical development – inadvisable (pp. 289-290). Be that as it may, in other places, Carnap admitted that his knowledge (and interest) in quantum mechanics was not as developed as that in relativity, which he had studied in Germany at the right time, and that he often had to rely on Reichenbach's advice (on quantum issues, see Chapter 22 by Toader). IPoS surely reflects this distinction in Carnap's interests, especially if we compare him to Ernest Nagel, Reichenbach, or even Philipp Frank. Upon the book's publication, Carnap was optimistic and hoped for a better future, where science, society, and philosophy would work hand in hand after a promised new breakthrough in physics: "Whether it will be soon or later, we may trust – provided the world's leading statesmen refrain from the ultimate folly of nuclear war and permit humanity to survive – that science will continue to make great progress and lead us to ever deeper insights into the structure of the world" (p. 292).

The Book's Impact

For many decades, Carnap's book was a classic of the field due to its stylistic simplicity and understandability, its sharpness of presentation that still left room for extra remarks and notices. Today, no one would presumably use IPoS as such, not necessarily because of what's there (one can always correct a philosophy book in light of the historical and systematic developments of the field), but mainly due to what is *not*: all the new issues and topics that now occupy philosophers of science.

But it is often forgotten by historians of philosophy of science that Carnap's IPoS was not just a classroom textbook, but a chance for him to reflect on philosophy of science in general, and on the history of the Vienna Circle in particular. He did both, and from this perspective the book is still a goldmine. One topic that appears throughout is the repeated emphasis on the interplay between conventional and non-conventional elements in concept and theory formation. Carnap aims for a refined middle position, rejecting Hugo Dingler's extreme conventionalism (Wolters 1985) while extending Poincaré's insights within geometry to some extent (both authors are discussed in some details on pp. 59ff.)

Besides the recurrence of conventionalism, there is no explicit and systematic meta-perspective as a separate issue, but from time to time, Carnap makes a few hints in this direction (for details and a systematic view, see Chapter 61 by Patton and Chapter 68 by Friedman). In the chapter on causality, for example, a notion that was often conceived as highly metaphysical (previously even perhaps by many logical empiricists), he defines and discusses the nature, tasks, and territory of philosophy of science. One can be a philosopher and a scientist at once, but one must be aware of the fundamentally different approaches. The latter asks empirical questions that can be worked out via empirical methods (experiments, observations, measurement), while the former turns "toward an analysis of the fundamental concepts of a science" and practices philosophy *of* science. This a highly abstract, conceptual endeavor, not the pursuit of "metaphysical truths" that represent even more fundamental aspects of reality, i.e., its final building blocks.

"The old philosophy of nature has been replaced by the philosophy of science," Carnap argues (p. 188), thus delineating the territory and methodological trajectories of twentieth century philosophy of science (see further Lutz and Tuboly 2021). Instead of truths and ontologies, philosophy of science is directed "toward science itself, studying the concepts employed, methods used, possible results, forms of statements, and types of logic that are applicable" (p. 188). Of course, according to Carnap, this is a continuum, not a sharp distinction, as philosophers *must know* the details of science, while scientists *have to* reflect on conceptual issues all the time. This reflection often reveals revolutionary changes (as in the case of simultaneity within relativity), while at other times "in the logical analysis of scientific method, we must make everything explicit, including matters that the man on the street takes for granted and seldom puts into words" (p. 71). This could also be the motto of Carnap's book.

For historians, as mentioned above, the book contains countless little stories and reflections on how the Vienna Circle changed its own perspective and inclination to cooperate instead of fight (by moving from the very hostile central European atmosphere to the more liberating environment in the United States, p. 12; see Chapter by 5 Tuboly and Chapter 6 by Damböck), how logical empiricists took seriously Hans Driesch's vitalism within the philosophy of biology (pp. 13-14), how now obscure German philosophers, like Bernhard Bavink, attacked their views, or how Hans Kelsen traced back the notion of laws (of nature) to their historical genesis.

Perhaps most strangely, Carnap does not discuss explication as a method of philosophy of science (besides one small remark on p. 190, see further Chapter 71 by Simion and Chapter 82 by Halvorson), although in the 1950s, he devoted long chapters and papers to this issue and defined it as *the* fundamental approach of philosophers engaged in housecleaning in the sciences and everyday life: in IPoS, explication instead became *purification*.

References

Creath, Richard: Carnap on Determinism and Free Will. In: Alan Richardson and Adam Tamas Tuboly (eds.), *Interpreting Carnap*. Cambridge: Cambridge University, Press, 2023

Lutz, Sebastian and Tuboly, Adam Tamas: Introduction: From Philosophy of Nature to Philosophy of Physics. In: Sebastian Lutz and Adam Tamas Tuboly (eds), *Logical Empiricism and the Physical Sciences*, New York and London, Routledge, 2021, 1–17.

Salmon, Wesley C.: Elemental Concepts of Science: Review of Philosophical Foundations of Physics. In *Science* 155 (1967): 1235.

Wolters, Gereon: 'The first me who almost wholly understands me': Carnap, Dingler, and Conventionalism. In Nicholas Rescher (ed.), *The Heritage of Logical Positivism*. London: University Press of America, 1985, 93-107.

Workman, Rollin W.: Review of Philosophical Foundations of Physics. In: *Synthese* 17 (1967): 366-367.