The Limited World of Science:

A Tractarian Account of Objective Knowledge

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Abstract

According to Wittgenstein's _Tractatus_, scientists determine the structure of the world by identifying the true propositions which describe it. This determination is possible because i) elementary propositions are contingent, i.e., their truth depends on nothing but agreement with what is the case, ii) completely general propositions delimit the degree of freedom which the totality of elementary propositions leaves to the structure of the world. Once such completely general propositions are adopted (e.g., the principle of conservation of weight), agreement among scientists can reduce to agreement among representations. On this account, Lavoisier's chemistry better promotes objective knowledge than Priestley's.

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In the *Tractatus Logico-Philosophicus* Ludwig Wittgenstein presents the limits of the sayable and the limits of science as a consequence of his theory of language (cf. 5.61f., 6.52, 7, *et al.*). In the following remarks I adopt an inverse perspective, emphasizing how only the limitation on the sayable and on the conception of the world makes possible the language of science which is the subject-matter of the *Tractatus*. Only insofar science conceives the world as a limited whole can it effectively draw consensus on theoretical representations of contingent states of affairs.[1]

After establishing this claim, I proceed to show how it helps us understand the Chemical Revolution: Lavoisier's modern chemistry prevailed because it renders theoretical propositions decidable within a carefully delimited chemical universe; Priestley objects to Lavoisier precisely because he refuses to limit chemistry in this manner.

I.

"The limits of my language indicate [or mean] the limits of my world." *Tractatus* 5.6 opens a short section concerned with questions of subjectivity and contingency and with the coincidence of solipsism and realism. It is wedged between two rather more extensive and technical sections which deal with the general form of propositions and the general structure of the world. The core idea which thematically ties the remarks on limits of language and world to the reflections that precede amd follow them in 5.5ff. and 6ff. is the notion of contingency:

> Everything we see could also be different. Everything we can describe at all could also be different. (5.634)

Within the field of vision and within a discourse of representation or description everything could be different and nothing is _a priori_. And just like "nothing about the field of vision leads to the conclusion that it is seen by an eye" as the necessary condition for seeing (5.633), there is nothing within the purview of description which leads to the conclusion that there must be a world or a knowing subject or an "_a priori_ order of things" (5.634).

Aside from setting epistemic limits or bounds [_Schranken_] to what is knowable, the contingency of all that can be seen or described establishes the seeing or knowing subject simultaneously as a limit to [_Grenze_] and a precondition of the world.[2] The "metaphysical subject" is not part of the world (5.641) but frames the world as one which is determined by what is contingently seen and described.[3] Within the frame, therefore, contingency constitutes sense, and the fact that everything could be different gives meaning to what, in fact, we see and describe. All this is established in the sections that come before and after these reflections on the limits of language and world.

Sections 5.5ff. and 6ff. of the Tractatus deal with propositions as products of truth-functional operations. We determine the world by deciding whether a proposition or its negation is true. The world can be determined in this manner only as long as propositions are decidable, and propositions are decidable only insofar as their truth or falsity is directly linked to the existence or non-existence of states of affairs. This linkage is ensured, of course, by the picture-theory of language. If any proposition designates a possible state of affairs, then a proposition is true when that state of affairs happens to actually obtain, and it is false when what is quite possible turns out not to be factual. And if the world is the totality of all true propostions, "the truth or falsity of any proposition changes something in the general structure of the world" (5.5262). However, the determination and description of the world emerges only gradually and may never be completed in this open-ended process of noting piecemeal what is contingently the case. The totality of elementary propositions or possible truths leaves the world a degree of freedom which can be delimited only by theoretical propositions, i.e., by the way in which the human mind frames contingency. Wittgenstein therefore acknowledges that

> One can describe the world completely by completely generalized propositions, i.e. without from the outset co-ordinating any name with a definite object. [...] The totality of elementary propositions leaves a degree of freedom [Spielraum] in the structure of world, and those most general propositions delimit precisely this degree of freedom. (5.526 and 5.5262)

Later on, Wittgenstein offers mechanics as an example for such a "completely general description of the world" (6.3432). Drawing on Hertz's demonstration that three different systems of mechanics can each describe all phenomena of motion, Wittgenstein notes in 6.342 that it says nothing about the world that it is describable by, say, Newtonian mechanics. The completely generalized systems of mechanics describe the world only by setting frames within which the facts contingently determine the structure of the world. Accordingly, it does say something about the world how it is describable by, say, Newtonian mechanics. Like the principles of causality, of continuity, of least expenditure in nature, any set of principles of mechanics represents an "understanding a priori of the possible forms which can be given to the propositions of science" (6.34). Rather than providing explanations of natural phenomena (6.371), completely general theoretical propositions tell us whether in the description of particular motions our elementary propositions concern forces acting on masses at a distance (Newtonian mechanics) or spatially and temporally contiguous systems of material points (Hertzian mechanics).[4] In either case, whether some particular description of motion is true remains entirely contingent upon which states of affairs actually obtain.[5]

The mechanical principles delimit the degree of freedom in the structure of the world. As such they make theoretical knowledge of the laws of nature possible by bringing the propositions with which we describe states of affairs to a unified form (6.341).[6] By the same token they frame the world as one which is determined by what is contingently seen and described (cf. page 3 above), i.e., they limit discourse to a discourse of contingency, a discourse revolving around more or less easily decidable descriptions, determinations, or representations of contingent states of affairs. The mechanical principles thus render the world a limited whole which is structured just as it happens to be; ("normal") science does not contemplate the world as a limited whole but determines its contingent structure[7]; the questions of science are answerable because their answer requires merely that true propositions are selected from the store of all propositions; these answers finally determine which of possible states of affairs actually obtain and thereby what the structure of the world really is.[8]

Wittgenstein's idealized reconstruction of the language-game of an idealized normal science illuminates its peculiar and powerful presuppositions about the relationship of language and world. If the success of science is defined by its ability to draw the consensus of critical minds[9], consensus on this account needs to rely neither on the political model of contractual agreement nor on the spiritual notion of unanimity or oneness of souls. Instead, science can succeed if the consensus among scientists appears to require nothing but the agreement between pictures. "The grammophone record, the musical thought, the score, the waves of sound all stand to another in [a] pictorial internal relation" where one picture can be mapped onto another according to some rule of agreement (4.014). Successful science establishes similar relations: Perceptual representations of natural phenomena can be modeled by experimental simulations, where theoretical models map onto linguistic representations, where my theoretical representation can be compared to yours and both of our representations can be decided to agree or disagree with standard (re)presentations of the phenomena. As Wittgenstein points out, however, this consensus among critical minds can be reduced to such an agreement between pictures only if the world is already conceived as a limited whole, thus allowing for routine decision-making on the agreement between our representations and the phenomena of nature.[10]

II.

The preceding Tractarian account helps explain both the pervasiveness and the exceptionality of consensus in science. In order to speak one language and compare our representations we have to agree on the world or share a form of life.[11] But the propositions submitted for comparison with other representations and with the world can be contextualized also within biography, cultural history, or a scientist's various networks of enterprise. We may therefore find that two scientists agree on a theoretical matter but that what they are agreeing on means something rather different to them in the contexts of their lives and thoughts.[12] And while Wittgenstein's account implicitly offers a criterion of sorts for successful science, it also anticipates the incommensurability of scientific researches which are premised on incompatible general descriptions of the world.

One of the most famous episodes of incommensurable scientific researches and of scientists living in different worlds is the Chemical Revolution of the late 18th century. As with all such cases, what needs to be explained is firstly why Lavoisier's modern or French chemistry replaced so-called Phlogistic chemistry, and secondly, what prevented Joseph Priestley or other defenders of Phlogistic chemistry from acknowledging the superiority of the new chemistry. The Tractarian account provides both explanations: the new chemistry was more successful in that it limited chemical discourse in such a manner as to routinize and draw consensus; but while the limitations made for more effective scientific discourse, they could not rationally compel Joseph Priestley to believe that a more constrained and effective conception of chemistry is closer to the truth than the open conception defended by him.

Wittgenstein offered the principles of causality, least action, gradualism or continuity of nature, and the various principles of mechanics as examples of completely general propositions in science. To this list might be added action at a distance, conservation of force, or Lavoisier's principle of the conservation of weight or mass:

> We may lay it down as an incontestable axiom, that, in all the operations of art and nature, nothing is created; an equal quantity of matter exists before and after the experiment. (1952, 41; cf. Siegfried 1989)

Lavoisier's axiom serves as a formal constraint on propositions about chemical reactions and on the number of possible states of affairs. Chemical reactions are no longer "indefinite problems which may be solved in a thousand different ways" (1952, 6)[13], but pose a definite problem to the chemist who has to account for the entire quantity of matter after the experiment: a full account is true and the problem solved if the states of affairs obtain which correspond to the various propositions making up the account. Lavoisier's axiom, however, is not metaphysically neutral and far from "incontestable." The idea that nature does not create anything new contravenes Priestley's view of the plenitude of nature, i.e., the idea that nature is an infinitely large storehouse of novelty, the gradual revelation of which is the prime business of the scientist. Moreover, while Lavoisier carefully tracks the quantity or weight of matter he thereby neglects the dimension of time. Whether a reaction is violent or protracted, it is not a historical process in which the passage of time contributes to change. While Lavoisier's axiom renders the chemical universe syntactically closed, Priestley would insist on its historical openness. For Priestley, the history of chemistry marks a particular chapter in the history of nature and human affairs: "At present all our systems are in a remarkable manner unhinged by the discovery of a multiplicity of facts," allowing for the faulty "political systems upon earth" to be replaced by the superior system of nature, thus "extirpating all error and prejudice, [...] putting an end to all undue and usurped authority in the business of religion as well as of science" (1970, 1:xliii, xxvi, xxiii).

By delimiting chemistry against natural history or the history of nature, Lavoisier also delimited it in respect to epistemology. As opposed to Priestley, Lavoisier did not see nature working on our minds. Instead nature is called upon only to agree or disagree with our ingenious constructions. Priestley suggested that we are

> too much in haste to understand, as we think, the appearances that present themselves to us. If we could content ourselves with the bare knowledge of new facts, and suspend judgment with respect to their causes, till [...] we were led to the discovery of more facts, of a similar nature, we should be in a much surer way to the attainment of real knowledge. (1970, 1:xxixf.)

Priestley's recommended procedure expects of the scientists to seek out the facts ingenuously and wait until that time "when all the facts belonging to any branch of science are collected, [and] the system [or theory] will form itself."[14] While Priestley therefore requires the immediate communication of all facts, Lavoisier maintains that

> Among the facts that chemists discover are many that have little significance <u>until</u> they are connected together and assembled into a system. Chemists may withhold facts of this sort and ponder in the quiet of their studies how to connect them to other facts, announcing them to the public only when they have been pulled together so far as is possible.

This limitation of the facts to the theoretically significant ones allows for truth "to be sought in the natural connection (_enchainement_) between experiments and observations, in the same way that mathematicians arrive at the solution of a problem by a simple arrangement of the givens."[15] The natural connection between experiments, observations, and propositions thus consists in an agreement among arrangements. If the agreement obtains, the propositions are true.

Lavoisier required that theory is confronted with the natural phenomena, and Lavoisier's modern chemistry is theoretical chemistry. In contrast, it is difficult to argue that there even was such a thing as Phlogiston theory. Pneumatic chemistry was a loose collection of practices, inspired by dynamic conceptions of elements and principles, the most prominent of which was phlogison. It had links to physics, metallurgy, pharmacy, as well as metaphysics, and while it boasted paradigmatic explanations of certain processes such as calcination, its many practitioners never subscribed to a unified doctrine or system of thought. While phlogiston was central to their pursuits, they professed no knowledge as to its nature and properties. Thus, while Lavoisier's chemists are united in efforts to confirm or disconfirm theoretical propositions, Priestley and his compatriots were seeking revelation and surprise.[16]

This difference of scientific pursuits defined the respective rôles of instrumentation. Lavoisier's paradigmatic instruments were balance and calorimeter, and their prime virtue was to provide precision measurements. Instruments were thus to deliver data input or a numerical response to theoretical questions. According to Joseph Priestley, however, due to their limited function within the confines of a given theoretical context the use of these instruments "extends no further than the views of human ingenuity" and thus they resemble works of fiction. In contrast,

> real history resembles the experiments by the air pump, condensing engine and electrical machine, which exhibit the operations of nature, and the nature of God himself. (1761, 27f.)

Of course, Lavoisier's carefully contrived use of instruments does not therefore reduce his chemistry to a work of fiction. And yet, the contingent empirical facts are framed by Lavoisier within a closed system of language and thought which is to satisfy aesthetic criteria. He therefore developed a system of nomenclature in which the names of substances reflect theoretical suppositions concerning their composition and efficacy (Morveau et al. 1787):

> Like three impressions of the same seal, the word ought to produce the idea, and the idea to be a picture of the fact. (Lavoisier 1952, 6)

Finally, Lavoisier limited chemical discourse simply by excluding phlogiston on the grounds that it is merely hypothetical, not necessary for explanations in chemistry, thus subject to Occam's razor. By doing so, he removed from chemistry a principle that Priestley considered as pervasive and powerful as gravity, an active principle of a productive nature, a spiritual dimension of matter on a par with magnetic properties, gravitational powers, and electric charge. To eliminate this principle from consideration on the grounds of parsimony was to diminish nature and thus to work against the historical process of an unfolding infinity of novel facts, it was to sever chemistry from the physics and from the metaphysics of matter. It was to place the ingenuity of the theoretician over the "natural ardour of mind" of those who "with an ingenuous simplicity immediately communicate to others whatever occurs to them in their inquiries" (Priestley 1970, 1:xviif.).

III.

The small sampling of features of Lavoisier's chemistry suggests that his construal of chemical problems constitutes a community of researchers engaged in a discourse of contingency, engaged in the production of representations of natural phenomena, representations that take their form from Lavoisier's methods and axioms and that are thus decidable simply by their agreement or disagreement with the facts. In contrast, Joseph Priestley belonged to a community of researchers involved in various intersecting discourses of contingency, history, and identity. He and his scientific peers situated themselves within a larger historical process. By letting nature work upon their minds and confront them with new facts, they would eventually learn the truth from nature. Their agreement with nature resulted from a natural ardour of mind and from their ingenuousness rather than ingenuity, i.e., from who they were and how they conducted themselves.[17]

It is easy to see on this account why Lavoisier's 'consensus-practices' proved more successful and productive than Priestley's, rendering proposed solutions decidable.[18] Consensus requires nothing but agreement among representations and agreement on what happens to be the case, what we see and describe within a carefully delimited field of vision.

Just like the rational reconstructions of Imre Lakatos (in terms of progressive and degenerating research programmes) and Philip Kitcher (in terms of the comparative facility or cognitive labor involved in accounting for novel facts) this reconstruction explains why Lavoisier's chemistry prevailed, but does not issue a rational standard which would have compelled Priestley to abandon phlogistic chemistry (cf. Lakatos 1978 and Kitcher 1993, 272-290). In this manner, perhaps, the history of science limits the philosophy of science, confining it to an investigation of the conditions under which communication, agreement, and consensus in science become possible.

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Notes

1. I cannot in this context defend my reliance on the Tractatus, a work apparently disowned by Wittgenstein himself. I would contend that, from the point of view of the Philosophical Investigations, the Tractatus was wrong in that it mistook a very particular language-game for language overall. Along the lines of this criticism, the Tractatus still provides a detailed transcendental reconstruction of that particular language-game which is the professed language-game of modern science.

2. I am alluding here to Allan Janik and Stephen Toulmin's discussion (1973, 148ff.) of the Kantian distinction between Grenze and Schranke and its bearing on Wittgenstein's notion of 'limit.'

3. Charles Sanders Peirce makes a similar move. According to Peirce, the scientific method of fixing belief frames reality as that which is the external cause of our perceptions and not influenced by how and what we think it is - but this "hypothesis of reality" results from an abductive inference and thus presupposes a mind.

4. As Hertz (1956) points out, his mechanics leaves less Spielraum [degrees of freedom] to the world than Newton's which allows for the possibility of motions that do not actually obtain.

5. Cf. 6.1232 in which Wittgenstein notes of propositions like "All humans are mortal" or Russell's 'axiom of reducibility' that, if true, these propositions "can only be true by a happy coincidence [günstigen Zufall]"; also: "The world is independent of my will" (6.373).

6. Cf. "The law of causality [or the principle of continuity in nature, etc.] is no law, but the form of a law" (6.32). But: "If there were a law of causality, it might run: 'There are laws of nature'. But that, of course, cannot be said: it shows itself." (6.36)

7. Cf. 6.45 and 4.113: "Philosophy limits the contentious [bestreitbar: disputable; also: decidable?] sphere of natural science." Cf. also Carl Friedrich von Weizsäcker's remark that "Each special science makes itself possible by no longer asking for the justification of its own principles" (1982, 12).

8. To posit the world as a limited whole therefore functions like a Kuhnian 'paradigm,' cf. Hoyningen-Huene (1993, 31-130).

9. Cf. e.g. Philip Kitcher's view of the history of science as a history of ever-improving consensus-practices (1993, 90ff.).

10. To Bruno Latour's paradoxical formulations of the constitution of science and nature (1993) can now be added: "Even though we carefully establish and maintain the conditions under which consensus becomes possible, we shall act as if the agreement was not between us but only between representations."

11. Cf. Philosophical Investigations, remark 241. and Davidson (1974).

12. For example, physicists at the end of the 18th century could routinely agree that a given body is positively charged. However, some meant by this that the body carries an excess of the one and only electric fluid, while others thought of the body filled with one rather than another of two electric fluids. (Also, they agreed that the question concerning the number of electric fluids is currently undecidable.) For another example, Jed Buchwald's close scrutiny of Heinrich Hertz's 1884 paper on extant theories of electrodynamics shows that, unbeknownst to Hertz himself, the term 'charge' has incommensurable meanings (1985, chapters 21 and 22).

13. The formulation occurs in a different context, namely to justify his operational definition of 'element' as the end-point of decomposition.

14. Quoted by McEvoy (1979, 24) from the History and Present State of Electricity.

15. The two passages from Lavoisier quoted in Donovan (1993, 54f. and 71).

16. While there was no such thing as the Phlogiston theory, Kuhn is nevertheless right to speak of a Phlogistonian paradigm, i.e., a set of practices and concerns revolving around Stahl's exemplary explanations e.g. of calcination.

17. Cf. the full text of Priestley's most explicit objection to Lavoisier (referring to himself as the discoverer of oxygen or 'dephlogisticated air,' and to Lavoisier whose claim to fame issued from his theoretical interpretation of 'oxygen'): "When for the sake of a little more reputation, men can keep brooding over a new fact, in the discovery of which they might, possibly,

have very little real merit, till they think they can astonish the world with a system as <u>complete</u> as it is <u>new</u>, and give mankind a high idea of their judgment and penetration; they are justly punished for their ingratitude to the fountain of all knowledge, and for their want of a genuine love of science and of mankind, in finding their boasted discoveries anticipated, and the field of honest fame pre-occupied, by men, who, from a natural ardour of mind engage in philosophical pursuits, and with an ingenuous simplicity immediately communicate to others whatever occurs to them in their inquiries." (1970, xviif.)

18. Lavoisier's modern chemistry thus seeks out what Paul Feyerabend (1989) has called "the path of least resistance."