SPLIT AND SPLICE

Hans-Jörg Rheinberger

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Hans-Jörg Rheinberger's latest book, *Split and* Splice, brings together and builds upon themes that are familiar from his previous works, in particular his highly influential *Toward a History of Epistemic Things* ([1997]) and his *Epistemology of the Concrete* ([2010]). Characteristic of all of these books is Rheinberger's skilful combination of a

profound knowledge of the history of biology with careful attention to the details of experimental practices in microbiology, and an ambitious, often dazzling, overarching vision of how to analyse what he deems most exciting about the scientific process, namely, that it can create novelty. It is this latter point, in particular, that sets his unique approach apart from much of contemporary history and philosophy of science in the Anglo-American tradition. Instead, his theoretical framework is deeply informed by the French tradition of historical epistemology, of which Bachelard and Canguilhem are particularly well-known figures. In addition, the book draws on a wealth of research from various other traditions and disciplines, often taking the accounts and observations of scientists as points of departure, combining them with concepts from philosophy, history, cultural studies, and STS, to weave together an evocative set of interlacing analyses of the scientific process.

The book offers, simultaneously, an account of scientific knowledge generation and a proposal for doing philosophy of science in a way that genuinely integrates it with the historiography of science. These two desiderata are closely connected for Rheinberger since, on his account, the historicity of scientific knowledge generation is integral to science. The thrust of the book is, of course, aligned with a broad range of approaches in the history, philosophy, and social study of science that have emphasized scientific practices, material cultures, and the historicity and perspectival nature of scientific knowledge. I will leave it to the reader to draw these connections, focusing instead on Rheinberger's unique contribution as he lays it out in this book.

Central to Rheinberger's analysis of the process of knowledge generation in science is the conviction that this process cannot be accounted for in terms of a simple opposition of the knower versus the known, the epistemic agent versus the objects of investigation. There is, Rheinberger suggests, a space in-between that allows novelty to occur, a space that makes creativity possible by offering a unique mix of material and cognitive constraints, on the one hand, and epistemic possibilities, on the other. Throughout the book, Rheinberger returns to the trope of the 'between', which he describes as a space of mediation between the subject and the object, and as 'a realm that is framed in such a way that novelty can come about inadvertently' (p. 11). The inadvertent nature of such 'epistemic events' (p. 128) is, of course, precisely what renders the topic of scientific creativity so elusive for the usual tools at the disposal of philosophers. This is likely one important reason why, as Rheinberger points out, questions about the constitution of the space between the knower and the known, about the types of epistemic environments that can give rise to knowledge, 'has remained epistemologically underexposed, despite the efforts of the contemporary practice turn in sociology, history, and, more recently, philosophy of science' (p. 47).

Split and Splice offers some tools to address this lacuna, tools that are as theoretically sophisticated as they are richly empirically grounded and illustrated. The book is organized in two parts (entitled 'Infra-experimentality' and 'Supra-experimentality') and comprises ten chapters. The central concept of the book is that of an experimental system. Roughly speaking, experimental systems are 'loose articulations of materials, research technologies, and procedures' (p. 104). Such systems play a crucial role in the constitution of the target objects (Rheinberger's 'epistemic things') as something one can make discoveries about. Experimental systems, Rheinberger tells the reader, 'consist of the research technologies that help give contours to the things of epistemic interest' (p. 105). They are the material assemblies that populate the 'in-between' space mentioned above, mediating between epistemic agents and their objects of interest. They play a crucial role in making things visible (chap. 3), thereby shaping, and potentially expanding, our very understanding of the things in question: experimental systems are 'techno-epistemic environments that allow us to transform things of scientific interest into phenomena that can be investigated materially' (p. 133).

Given their central status as mediators in the research process, experimental systems are also—according to Rheinberger—the natural units of analysis for any attempt to understand the dynamics of experimental research. Part 1 focuses on material and cognitive processes that can occur within specific experimental systems, whereas part 2 focuses more on the communicative and social aspects of research, covering cultural techniques such as

note-taking, as well as practices of transferring objects and component parts between systems. In the second part, thereby, the notion of the in between is expanded to draw attention to the epistemic dynamics that can unfold at the larger scale of different experimental systems, laboratories, and even disciplines.

In simple terms, one of the issues at the heart of Rheinberger's analysis concerns the role of technologies in the research process. Technologies are, as he puts it, 'components of knowledge environments in materialized form' (p. 134). With this phrase he captures two interlocking central ideas, namely, that specific environments can be conducive to knowledge generation, and that the technological components of such environments—themselves—constitute epistemic achievements. The former idea is connected to Rheinberger's insight (mentioned above) that technological possibilities shape how research objects are conceptualized and rendered physically tangible. The latter idea refers us back to Rheinberger's distinction between epistemic and technical objects, familiar from his previous work, which acknowledges that technologies are those components of research that are, for the time being, taken for granted, but which can become objects of our epistemic attention again. This has two important consequences. First, it rules out any suggestion of technological determinism: while the technologies employed within a given experimental system shape how knowledge about things is generated, those things can also push back in ways that necessitate technological changes. Second, Rheinberger's proposal hints at the possibility of scientific progress that is not cumulative: knowledge generation builds on previous epistemic accomplishments, but this does not mean that the 'materialized form' of those previous accomplishments do not, themselves, undergo changes (or perhaps even get abandoned) in the face of new epistemic challenges.

Throughout the book, key analytical concepts are introduced and explained alongside detailed case studies from the history of experimental biology. Chapter 1 introduces the technology of radioactive tracing to illustrate Rheinberger's account of the distinction between traces and data and to drive home the point that our experimental knowledge about the objects of microbiology is highly mediated by techniques designed to make those objects 'visible'. This means that (for example) the history of our knowledge about molecular structures cannot be told without covering (among other things) the history of the techniques that made the production of radioactive traces possible. Rheinberger also suggests that a philosophy of science that brackets the complicated and sophisticated background of any experimentation, both in its historical and physical dimension, cannot address what are—for him—crucial aspects of science, namely, its temporality and its deep embeddedness in the material world. This background, his analysis suggests, cannot be relegated to something like the context of discovery but deserves to be analysed philosophically in its own right. By pointing to the temporal and material nature of science, Rheinberger means more than the (trivial) fact that scientific research processes occur in time and space, but draws our attention to the fact that research technologies often operate by compression and dilation: they speed up and slow down processes of interest in ways similar to using imaging technologies and models to scale physical entities up or down (chap. 1 and chap. 3).

The case of radioactive tracing—like those of radioactive isotopes, ultracentrifugation, chromatography, transmission electron microscopy, and plaque techniques (chap. 3), and the prevalence of modelling techniques and models (chap. 2)—brings out another important feature of Rheinberger's analytical apparatus, namely, his argument that the creative process often involves the 'transposition' of elements from one domain to another, juxtaposing objects that don't seem like an immediate fit. This kind of juxtaposition, again, conjures an image of a space in between that can create epistemically productive friction. For him, the combination of, and playing around with, (seemingly) non-fitting parts is another component of the experimental process that allows for knowledge to be generated. This idea is illustrated by reference to the concept of grafting (chap. 4), a concept taken from the biological technique of bringing two types of organism together with the aim of supplanting undesirable (for the purposes at hand) qualities of one organism with desirable qualities of the other. Rheinberger carefully distinguishes the technique of grafting from other, similar techniques, such as vaccination,

transplantation, and hybridization. The crucial difference is that in grafting the two elements remain distinct, and this is precisely why, when combined with one another, they can be productive in the intended (but perhaps, sometimes, also unintended) ways. This is significant insofar as it mirrors the metaphor behind the title of the book: *Split and Splice*. As he explains, he uses the terms 'split' (rather than 'analyse') and the term 'splice' (rather than 'synthesize') to express his overall contention that the processes that drive scientific creativity cannot be decomposed into neatly divided packages or understood as the merging of components without remainders. The components of experimental systems, the argument goes, often keep their identity. This can make for an uneasy fit between pieces that are jagged at the edges, but it can also generate the creative tensions that make novelty possible, and this makes it possible for experimental systems to reconfigure and for their parts to travel, as indicated above.

The example of grafting as a concept that describes a scientific and technological practice while at the same time serving as an analogy for an aspect of the process of knowledge generation is typical of Rheinberger's style, which happily embraces ambiguities, often sliding effortlessly from the neutrally descriptive to the metaphorical, from the sober to the poetic, from the predictable to the unexpected, and, sometimes, to the unexpectedly beautiful. There may be moments where this style is challenging to readers entrenched in the Anglo-American tradition of philosophy of science. It is important to recognize, however, that Rheinberger's stylistic choices are deeply intentional: By providing an account of experimental research that is centred around key practices, their objects, and the conditions of their technological possibility, Rheinberger simultaneously tells a story about the emergence of scientific novelty and shows (rather than tells) the reader how, according to him, such a story has to be told, namely, by following the 'logic' of experimental systems rather than that of the epistemic agents. The book, thus, contains a meta-narrative about the creative process of historiography. Historians of science, just like scientists, face situations of epistemic openness. The texts, notes, images, and graphs that historians unearth and analyse are analogous to the traces that experimental researchers encounter in their laboratories. This means that historians, too, need to acknowledge the importance of the space in between for their own epistemic endeavours.

Rheinberger frequently introduces specific concepts that have multiple layers of meaning, using them, sometimes simultaneously, to construct a story of conceptual change, to highlight parallels between different levels of analysis, and to propose an explanatory relation. The concept of culture, for example, is used to tell a fascinating story of the history of microbiology as centred around shifting understandings of the relationship between *in vitro* and *in vivo* research (chap. 5). Cultures as something that can be grown in test tubes are material objects, but, at the same time, these material objects are central to the epistemic aims of specific communities of researchers who use them, manipulate them, and reason about them. In other words, they are central to the experimental culture of this specific tradition. Again, the shift between bacterial cultures and cultures of research is not a mere rhetorical trick or lofty metaphor. The way I read it, it is intended to bring across a deep commitment of the author, namely, that the traditional distinction between the physical world and the knowing subject (or groups of subjects) falls short of explaining scientific novelty. Human cultures are geographically and historically situated, and test-tube cultures require humans for their design and maintenance. Jointly, they constitute a space in between. Telling the history of microbiology as being either about its objects or about the theoretical and inferential practices of its epistemic subjects, Rheinberger suggests, fails to address what makes novelty possible. This is a very concrete example of how the space in between can play out and, at the same time, it is a metaphor for other research contexts that don't use test tubes. The example also illustrates Rheinberger's contention that his account 'points beyond the dichotomy between self-disclosure and constructivist relativism regarding scientific knowledge' (p. 133).

The book provides countless accounts of specific episodes from the history of biology and presents an intricate ensemble of analytical concepts to make sense of those episodes. It is no accident that we are looking at a whole

ensemble: What Rheinberger is suggesting is that, as scholars of science, we need a rich array of epistemic tools to do justice to the generation of scientific knowledge, just as experimental researchers make use of multiple tools in their endeavours. In this vein, it seems clear that no single analysis of the 'in between' will be sufficient. Reasons for this are, first, that each and every research tradition and experimental system consists of multiple epistemic and technical components (as the book amply illustrates) and, second, micro-historical investigations of different areas of research may require different approaches and analyses. Rheinberger highlights this latter point toward the end of the book, arguing that '[w]hat we need is a multi-perspectival view from below' (p. 146). At the same time, he wants to distinguish his vison of micro-history from that of 'a mere local history', by suggesting that micro-historical analytical concepts have the potential to 'point beyond themselves' (p. 147).

It is this latter suggestion that I found particularly intriguing because it resonates with perennial questions about how the philosophy of science and the history of science can be integrated. What does it mean for a historiographical category to 'point beyond itself'? Rheinberger seems to be suggesting here that there is still a general story one can tell about science, despite the particularities of its instances. For Rheinberger, this story is an epistemological story because it pertains to the epistemic (rather than, for example, institutional or economic) aspects of science. But, on his construal, the epistemological question at stake pertains to the generation of scientific novelty, that is, to a process. In turn, this means that for any given case, the epistemological analysis in question is necessarily also a historical analysis. This is why Rheinberger calls his approach 'historical epistemology', making clear that the history of science and the philosophy of science are inseparable. They are two sides of the same coin. From this perspective, the question of how to integrate the history of science with the philosophy of science makes no sense: they are not really separate to begin with. There is—so to speak—no space in between.

Split and Splice is thought provoking and original. Its background assumptions and arguments concerning both subject matter and method of epistemology clash with received notions in the philosophy of science. This is precisely why philosophers of science should read this book. It challenges the still prevailing focus on finished scientific products (for example, theories) in favour of trying to understand the scientific process itself. It also challenges the very analytical categories and methods typically employed by philosophers of science. Thus, it has the potential to create productive frictions and, thereby, to stimulate important discussion within philosophy of science.

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