

2 What Is Narrative in Narrative Science? The Narrative Science Approach

Kim M. Hajek

Abstract

In current English, the term ‘narrative’ covers a lot of conceptual ground – from an overarching position on some big issue, to all kinds of storytelling, to a general attention to language or metaphor. This chapter argues for narrowing our conception of ‘narrative’ to add value to scholarship in the history and philosophy of science (HPS). This narrower Narrative Science Approach treats narrative as a distinct and complex discursive form, subject to careful technical theorizing in its own right. By using analytical categories from narrative theory, we can identify in rigorous detail how scientific narratives are put together, what might distinguish them from other narrative forms, and the questions they raise for HPS and narrative enquiry. Similarly, when scientists use narrative ways of reasoning, tools from cognitive narratology enable us to reconstruct their imaginative activity. As a reciprocal movement, our Narrative Science Approach promises to enrich narrative studies.

2.1 Introduction: Narrative and the Narrative Science Approach

What do we mean by ‘narrative’ in enquiry into narrative science? How does the Narrative Science (NS) Approach relate to other scholarly interest in narrative? In everyday English, we most often encounter ‘narrative’ used to refer to an overarching position, or set of positions, on some issue – for example, there are competing ‘narratives’ of climate change,¹ while marketers for a brand develop its ‘narrative’ to appeal to particular consumers (see, e.g., Salmon 2008). More basically, ‘narrative’ serves as a synonym for ‘story’. The two gather literature into their associative constellation, such that it could seem straightforward in 2010 for Laura Otis to claim a ‘close affinity’ between literary studies and work in the

¹ This is narrative in its noun form, unlike in French, for instance, where *narratif* exists only as an adjective. Cf. Elisa Vecchione’s talk in the NS Public Seminar Series, 9 October 2018 (www.narrative-science.org/events-narrative-science-project-public-seminar-series.html).

history (less so philosophy) of science, due to a ‘common focus on narrative’ (Otis 2010: 570). With the overlapping ‘linguistic’ and ‘narrative’ turns, historians have read scientific documents ‘like novels’ (Carroy 1991: 22),² and sometimes joined literary scholars in tracing patterns of influence, shared elements or dissonances between scientific and fictional texts. These approaches have been enormously fruitful, but they disperse their analytic gaze over a wide and highly varied field of view. On the one hand, most studies in literature and science have tended to concentrate their attention on one or the other kind of text – usually novels, since most work in this domain is undertaken by literature scholars.³ Much rarer are investigations which take full advantage of the potential for careful, detailed exploration of formal reciprocities and intersections between narrative fiction and scientific writing (Vila 1998 and Griffiths 2016 are two examples).⁴ On the other hand, when it comes to scientific texts, ‘narrative’ stands in too often for what is primarily an attention to language or metaphor, as in Otis’s 2010 reflections. When narrative appears in such broad terms, it loses its value as a distinct category of analysis. This chapter aims precisely to recover narrative as a discrete analytical category – of significance in its own right, and also as one mode of writing and thinking to be investigated alongside metaphor, themes, argument, genre, etc. in scientific texts and their literary counterparts. In promoting this ‘Narrative Science Approach’, I construe narrative in the specific technical terms of narratology.

Narrowing our perspective in this way has value, first, for understanding the histories and philosophies of science (HPS). As Kent Puckett (2016: 8) puts it, ‘looking at and naming different aspects of [narrative] gives us the ability *to see* what is weird about almost any narrative’. Narratology (or narrative theory)⁵ provides technical concepts and well-determined labels with which to discuss aspects of narrative; this chapter elucidates some fundamental narratological ideas for HPS scholars (my first set of readers) and demonstrates how these concepts help open up a peculiar set of features of scientific activity – ones we call ‘narrative’. Scientific texts are my priority, as they are in this volume and the wider NS Project; novels make few appearances in these pages. The formalized, technical framework of narrative theory lets us defamiliarize aspects of standard scientific texts like experimental research articles, but also to study how diagrams or computer-simulation movies function in story-like ways – I encompass

² Already in 1885, naturalist Jules Claretie – who aimed to contribute to science – had a character in one of his novels read scientific research on hypnotism ‘as I would read a novel’ (see Hajek 2016b).

³ Buckland’s (2013) *Novel Science* is just one example, from an English literature scholar linked to the NS Project. Jacqueline Carroy’s (1991) work stands for a primarily historical approach (www.narrative-science.org/events-narrative-science-project-publicseminar-series.html).

⁴ Caroline Levine’s (2015) *Forms* calls for comparative investigation of forms across disciplines.

⁵ I use the two terms interchangeably, although like in all academic disciplines, individual scholars frame their disciplinary allegiance in different ways.

all of these scientific outputs under the term ‘text’.⁶ With tools from narratology, we can also point to imaginative processes undergirding certain forms of scientific reasoning. My analysis draws together the narratological work done in this volume and unpacks its workings, with the aim of promoting further use of rigorous narrative theory by scholars in HPS.

Such a NS Approach, secondly, has benefits for narratology more broadly, as well as for interdisciplinary research into literature and science. I thus also address this chapter to scholars in literary and narrative studies. (Indeed, bringing together a dual readership follows readily from my own interdisciplinary interests, and accords with the multidisciplinary of the NS Project.) My analysis offers these readers an exploration of particular ways that narrative analysis plays out in historically and scientifically detailed enquiry. The contextual and technical expertise of historians and philosophers leads to perhaps surprising insights, which can, in a reciprocal movement, feed back into the work of narrative scholars. Studies of the kind in this volume provide much-needed, fine-grained analyses of non-fiction narratives in their particular historical and disciplinary contexts, for instance.⁷ They also open up arenas for productive comparison of scientific and literary texts in strict formal terms. My argument, then, brings narratological endeavours – including the growing field of factual narrative – and HPS studies into dialogue, for the benefit of both areas of scholarship.⁸

What the chapter is not, is a comprehensive introduction to narratological concepts – there exist many handbooks and critical introductions for that purpose.⁹ Nor do I survey all the ways narratology could inform HPS scholarship. Rather, following Morgan and Wise (2017), I concentrate on how scientists use narrative when *doing* science – as opposed to when they popularize it, or formulate an argument for a wider audience – and what narratological concepts enable us to see and say about such uses. Analyses from the NS Project serve as my principal examples; indeed, even where narratological concepts do not appear explicitly, they wind through many chapters in this volume, providing more or less implicit support to contributors’ arguments. My purpose here is thus twofold. In serving as an introduction to this volume, this chapter sets out how the NS Project thinks about narrative qua narrative. One might say the chapter ‘translates’ commonalities in contributors’ approaches into (some of) the terms of narrative theory. But, like all translations, mine is not neutral; this is *my* analysis of how narratological concepts provide an angle of entry into this

⁶ This follows standard usage in literary and cultural studies.

⁷ Monika Fludernik (2020: 63) calls for such finer examination.

⁸ In this, I also respond to Herman’s (1998: 383) contention that ‘what is needed is a more dialectical approach to the science-narrative nexus’.

⁹ Some examples are Herman, Jahn and Ryan (2010); Culler (2011); Puckett (2016); Hühn et al. (2014); Fludernik and Ryan (2020).

collection. At the same time, the chapter stands on its own as a proposal for what narratology and HPS have to offer each other as fields of enquiry, and where that kind of dialogue might lead. My argument both complements and sits as counterpoint to Mary Morgan's introduction (Chapter 1) – quite deliberately; each of us offers ways of looking at this collection of essays and at wider scholarly themes that intersect them. We just do not take quite the same angle of vision. Commentaries by Sharon Crasnow and Norton Wise do similar kinds of work at the mid- and end-points of this volume (Chapters 11 and 22).

Use of narrative spans the sciences – mathematical, natural, human and social – as Morgan outlines in detail in Chapter 1. For the purposes of this introduction, I identify two major classes of narrative knowing, each of which is particularly susceptible to investigation using a particular kind of narratological tool. In the first place, there is the '*mise en mots scientifique*' (after Acquier 2010), or the '*mise en récit*' (putting into narrative): the (re)presentation of scientific activities or findings in textual form, be that written, visual or spoken. Such texts, as material expressions of scientific work, are at once a product of scientific activity (think of a research article) and an index to the active process of narrative-making. Seen as output, the substantive '*mise en récit*' takes nominal (noun) form – as *a* narrative – and overlaps with what Morgan calls 'narrative representations'. Activity, by contrast, is verbal; what I see as the active flip side of the same '*mise en récit*' is Morgan's 'narrativizing'. But, where Morgan treats the two as separate but related functions of narrative in science, I argue that they are thoroughly, even necessarily, interdependent when seen through the lens of narrative theory. Noun and verb, narrative-as-made and narrative-making, are two sides of the same coin. Both lend themselves to analysis through the output form, the text. Concepts from classical narratology serve to unravel this doubled nature of scientific narratives, as well as to pull out ways in which the events/phenomena to be recounted might differ from the *way* they are represented – which plots are told, from whose perspective, whether there are flashbacks. Such questions ultimately relate back to the fundamental distinction in narrative theory between *story* and *discourse*; this distinction, and what it reveals about scientific activity, is the subject of section 2.3 of this chapter.

Before undertaking this work of unpacking, however, it is worth asking where scientific narratives – as output, noun, representation – sit in relation to the kinds of texts usually studied by narrative scholars. This question is the subject of section 2.2. Until recent interest in 'factual narratology' (see Fludernik and Ryan 2020), and even now, narratological categories have predominantly been applied to literary texts, which are readily accepted as being narrative in nature. The NS Approach, by contrast, does not formulate an a priori definition of what counts as a scientific narrative before asking whether we can productively employ narratological tools to unpack (some of) its

functions.¹⁰ Rather, contributors to the NS Project have examined both scientific narratives in the uncontroversial sense (like medical anecdotes or psychological case histories), and also (and more frequently) portions or characteristics of texts that might more readily be called ‘reports’, ‘accounts’ or just ‘articles’.¹¹ (Indeed, the French term I have been using, ‘*récit*’, encompasses both forms.) The broad features of scientific narratives that I develop in section 2.2, using Ryan’s (2007) elements of narrativity, thus emerge a posteriori from the NS Approach.

This definitionally flexible approach becomes especially evident in my second class of narrative knowing in science. Similar to Morgan’s notion of ‘narrative reasoning’ (Chapter 1), I construe this form of knowing as something that a scientist does with a scientific text. Each of us places the emphasis on a different word in the pair, however. Reasoning is privileged by Morgan under her functional approach as something scientists do *with* and *within* narrative representations – a deliberate cognitive process, distinct from imagining or affective reactions. By contrast, I understand ‘narrative reasoning’ as cognitively broader, involving imagination, affect and reason, in variable combinations. What matters for me is the combined result of these cognitive processes: story-like representations constructed in the mind/imagination of scientist–readers as they undertake some scientific activity (reading mathematical proofs, interpreting diagrams, framing their field).¹² The attention here is on the reader’s reception of a scientific document, and how it might share cognitive features with the reading of (literary) narratives, without presuming that the document is itself *a narrative* (representation). Ideas from cognitive, or post-classical, narratology are notably helpful for examining reader responses; I discuss these in section 2.4.

Importantly, this interest in narrative modes of reasoning does not mean the NS Approach makes any broad claims about narrative as a mode of human cognition; even less do we claim epistemic priority for narrative knowing. For all our definitional flexibility, we therefore set aside the perspectives of thinkers like Paul Ricœur (e.g., Ricœur 1980) or Jerome Bruner, for whom narrative fundamentally structures one or more functions of human thought (see Crossley 2010). Asking how narrative modes might enter into human cognition in general is a valuable question; it is just not one that we find particularly helpful in the context of this project. As David Herman presciently remarked in a 1998 commentary, claiming primacy for narrative is to set up an ‘idyll of

¹⁰ This contrasts with the focus on questions of fact, validity, authenticity etc. often present in analyses of ‘factual narratives’ (see science-related articles in Fludernik and Ryan 2020).

¹¹ The range of scientific documents examined under the NS Approach is showcased in *Anthology I* and *Anthology II*.

¹² Although I refer in this chapter to ‘readers’ (of written texts), many of the arguments developed could also be extended to ‘listeners’.

narrative' (1998: 385), which essentially only reverses the epistemic hierarchy present in earlier philosophers' 'myth of science as univocal rationality' (Herman 1998: 384).¹³ Either hierarchization precludes fine-grained attention to the contextual nuances of science and narrative studies as historically evolving activities.

It is the evolution and intricacies of scientific activity which concern us in this volume; concomitantly, we do not take account of the historicity of narrative theory as a field of study. Rather, we make flexible use of a range of concepts from narratology and use them to interrogate the doing of science in its active sense: what in science is about narrating, constructing narratives, reading narratives? The narratological tools we employ, the places we find narrative, thus expand and contract with the contingencies of our case studies, and tend to draw from varied perspectives within narratology as a field of enquiry.¹⁴ I reflect in my concluding remarks on what it might mean to look for narrative knowing in a historicized science of narratology.

2.2 Narrativity of Scientific Narratives

When asked, 'what is a narrative?', common usage, like some cognitive-science perspectives (Crossley 2010), holds that humans are innately able to recognize story-like configurations. Morgan, in Chapter 1, circumscribes the domain of scientific narrative along functional lines – what it does for scientists alongside or in place of tables, models, diagrams and so on. For their part, narrative scholars have long striven to develop a precise and logically coherent definition of narrative.¹⁵ But NS contributors rarely begin with these kind of definitions, or even ask explicitly, 'is it a narrative?', about the documents or actions they propose to analyse.¹⁶ Rather, as illustrated in this volume, contributors find it more immediately significant to plunge into examining a given document's (or action's) narrative characteristics and how those function.¹⁷ This notably allows attention to the fragmentary or lumpy ways that narratives can appear in scientific work, which might be overlooked under too stringent an initial categorization.¹⁸ Andrew Hopkins (Chapter 4), for instance, identifies sentence-level narrative chunks in geological research articles. These highly

¹³ See Olmos (Chapter 21), for a detailed dissection of such philosophical claims.

¹⁴ I thus construe our flexibility as a strength, against Herman's (1998: esp. 381) implicit desire for definitional clarity.

¹⁵ For a nuanced account of narratology's historical development, see Puckett (2016). Ryan (2007) gives a useful overview of more recent definitional stances.

¹⁶ As per Marie-Laure Ryan's (2007) perspective on definitions.

¹⁷ Meunier (Chapter 12) and Berry (Chapter 16) each develop more explicit definitions of narrative.

¹⁸ See Morgan (Chapter 1) for ways that small narrative chunks in scientific texts relate to other cognitive elements of those texts.

condensed narratives recount the transformations undergone by a rock formation, but are chiefly only recognizable as narrative by trained geologists. The narrative lies between the textual lines of the document,¹⁹ so to speak, a point which emerges secondarily from Hopkins's study.

In this section, I explore several characteristics of scientific narratives that can be identified through NS enquiry, taking narratologists' definitional frameworks and theories as a sensible starting-point. Such comparison is additionally essential to developing a genuine dialogue between narrative theory and science studies. My preference is for Marie-Laure Ryan's (2007: esp. 28–31) manner of classifying narratives according to a 'fuzzy set' of conditions on their narrativity.²⁰ Ryan lucidly divides the degree of narrativity of a given text into a number of 'dimensions' and 'conditions' that span narratologists' instincts and preoccupations regarding what narrative is. By using her scheme, we evaluate the degree of narrativity shown by a given document, not whether it should be ruled out (or in) as *a* narrative. Here, I work with three of Ryan's conditions in order to interrogate some salient features of scientific narratives: whether characters in a story are individuals with a 'mental life'; the importance of the 'temporal dimension'; and the issue of narrative 'closure'.²¹ My discussion, drawing iteratively on chapters in this volume, opens up a few intriguing narratological features of scientific narratives – which may, in turn, inform further categorization work on narrative.

2.2.1 *Narrative Protagonists*

One of Ryan's conditions on narrativity that resonates with everyday experience and literary studies is the requirement for narratives to contain some 'intelligent agents', with mental or emotional responses (Ryan 2007: 29). That is, a text has lower narrativity if it lacks this kind of 'mental dimension'. Hopkins's mini rock-narratives are one example; rock formations as agents have no mental reactions. What is immediately evident from the NS Project, therefore, is the need for a capacious approach to characters in scientific documents, because otherwise many texts would be ruled out of consideration as narratives. Scientific narratives very often recount transformations undergone by protagonists (main characters) that are neither human nor necessarily anthropomorphized: in this volume, the Stac Fada Member (Hopkins,

¹⁹ This is the cognitive narratologists' criticism of definitions that restrict narrative to being a text-type, rather than (also) a cognitive style (e.g., Ryan 2007: 27–28).

²⁰ Norton Wise, in contrast, draws heavily upon notions of experientiality in his commentary (Chapter 22), as he explores narrative as a style of thinking in scientific activity.

²¹ Ryan's (2007: 29) four dimensions comprise the spatial, temporal, mental, and formal and pragmatic. I set aside her 'spatial dimension' and examine one condition from each of the last three dimensions.

Chapter 4), the Tohoku earthquake (Miyake, Chapter 5), organic molecules (Paskins, Chapter 13) and substances in the fruit fly (Meunier, Chapter 12).²² The first two examples involve narratives about *particular individualized* protagonists; there is only one Stac Fada Member – a spatially localized rock formation – only one spatially and temporally circumscribed earth rupture process that was the Tohoku earthquake. Hopkins and Miyake do each nonetheless unpack ways that these particularized narratives inform or are informed by generalized knowledge in their fields. On the other hand, organic molecules and biological substances are already less individuated, more *generic*, narrative agents; even though the fruit fly narratives distinguish between particular substances (e.g., cn^+ or v^+), all the instances of cn^+ are held to be identical (indistinguishable) and to behave in a uniform manner across all fruit flies. When cn^+ is the protagonist in a fruit fly narrative, therefore, it stands in for a class of identical cn^+ substances, to be distinguished only from other generic character-substances (such as v^+).

Robert Meunier (Chapter 12) characterizes the narratives scientists tell about such entities as ‘narratives of nature’; they relate what ‘happen[s] [. . .] when no researcher is intervening or even watching’. As narratives of nature are abstracted, and become part of the acquired knowledge in a scientific discipline, the phenomena they relate also tend necessarily to become stabilized. Their narrativity correspondingly decreases, according to Ryan’s schema; at the abstract, generic limit, narratives of nature tell of (what have come to be seen as) habitual physical events, undergone by generic protagonists without a mental life.²³ As such, these narratives tend archetypally to fulfil conditions of factuality (or posited factuality) in a given scientific field.²⁴

By contrast, mentally reacting protagonists act in particular situations in Meunier’s other category of narratives: scientists’ ‘research narratives’. Here, scientists appear as characters performing specific actions (like steps in an experiment), and their reasoning processes or emotional reactions are often revealed through focalized narration.²⁵ Ryan’s condition about ‘mental life’ in narrativity thus plays usefully into the distinction between Meunier’s two categories of scientific narratives. For again, the scientist–protagonist may

²² The plant narrators discussed by Griffiths (Chapter 7) occupy an intermediate space, partly anthropomorphized through their interactions with (and explicit framing by) the Darwin family. For anthropomorphized accounts in eighteenth-century natural science, see Terrall (2017).

²³ Very many contributions to the NS Project examine narratives of regular phenomena, even when those are anthropomorphized; in Beatty’s (2016) terms, the regular is narrative worthy for science through its consequences for knowledge.

²⁴ As ‘stories of the facts’, narratives of nature would seem an ideal subject for those invested in questions of factual narratology – provided they are not first ruled out *as* narratives (cf. Fludernik and Ryan 2020).

²⁵ For HPS readers, I will explain focalization in section 2.3. Milne (2020: 449–51) builds on some earlier work of the NS Project (Morgan and Wise 2017) to distinguish between narratives with scientist-protagonists and those involving anthropomorphized objects of study.

either be *individualized* – like Charles Darwin (see Chapter 7) – or *generic*, standing in for all scientists in a field (see Chapter 12).

Examining Meunier’s categories in detail can provide insight into the way a given scientific activity functions. The prevalence of a research narrative in an experimental research article helps familiarize its reader with a new approach, especially when, as Meunier demonstrates, the scientist–protagonist becomes generic, allowing the reader to imagine herself in that place. Alternatively, that both categories of narrative are intrinsically bound together in archaeological dating practices is fundamental for Anne Teather’s (Chapter 6) proposal for archaeology to become more reflexive about how research questions influence the narratives it tells about the past. Across studies from the NS Project, we mostly see that, as a field of enquiry develops, its research narratives, with their individual actors and dimension of mental life, yield place to the telling of narratives of nature. This has even led contemporary chemists to call for ‘thin’ narratives of nature, like chemical reaction schemes, to be ‘thickened’ by reinsertion of the research story (Paskins, Chapter 13). Where the two categories of narrative are less distinct is in precisely those sciences which study the human, such as anthropology or psychology. Early psychological case histories, for example, weave together narration focalized on the mental processes of both individual subject and individual scientist–observer (Hajek 2020).²⁶ Can (or should) we distinguish the interplay of ‘research narratives’ and ‘narratives of nature’ as psychologists start to worry about the effect of their acts and thoughts on their subjects of study?

2.2.2 *Time in Scientific Narratives*

For the vast majority of narrative scholars, it is an essential condition of narrativity that a text deal with events that progress in time; an account of events occurring in a single moment could not be a narrative, for instance, nor could a series of instructions. This is largely taken for granted, such that questions of time in (especially classical) narratology are chiefly a matter of differences between the story and discourse in the ordering or duration of events.²⁷ Many scientific narratives similarly have what we might call a ‘fundamental linearity’²⁸ – a straightforward, and highly significant, temporal structure – particularly those of the so-called historical sciences (geology, evolutionary biology).²⁹ Other work in the NS Project, however, has opened up the question of the relative importance of time sequencing, in comparison

²⁶ As, necessarily, do most psychoanalytic studies, into the twenty-first century (see Scheidt and Stukenbrock 2020).

²⁷ I return to these questions of narrative order in section 2.3.

²⁸ I thank Martina King for this term.

²⁹ See, especially, chapters by Hopkins (Chapter 4) and Griffiths (Chapter 7).

with other kinds of ordering that make meaning in a narrative. Mary Morgan's (Chapter 1; Morgan 2017) notion of colligation privileges relations between disparate items brought together by virtue of a single framing, which may then be woven into nets of similarities and differences; here, orderings other than time are the 'grid' by which narratives structure their meaning. Both Morgan (Chapter 1) and the recent work of Carrier and colleagues mark a clear separation between such 'configurational or coherentist' narratives (Carrier, Mertens and Reinhardt 2021: 20) and their time-ordered counterparts. Certainly, the two make sense of their subject matter in different ways – according to different 'grids', to use Morgan's terms. Yet the gulf between them is precisely about differences in *function*, rather than in *narrativity*, and we should not assume that 'configurational' scientific narratives are not also situated in time. It is simply that the time dimension is more or less implicit in the length and order of their 'events', as we can see from examining how 'configurational' narratives are structured and are transposable.

Chemical reaction schemes provide one example of a scientific narrative that is structured by principles other than time. Each of the diagrams in Paskins's chapter (Chapter 13) proposes to answer the puzzle of how the molecule tropinone might be synthesized from a combination of other organic molecules. The structural formulae on the diagram are ordered under a causal logic and selected according to whether they show key stages in the transformation of the starting molecules (such as proton transfer or a rearrangement of chemical bonds). If this causal ordering is also implicitly a *sequence* in time, the *duration* of each step (between the arrows) is subordinate to consideration of which transformations take place, and which chemical substances are added to or removed from the reaction vessel (see, e.g., notations above and below the arrows).³⁰ Transformations, not duration, are what matters for chemists. These configurations are also of principal import for NS scholars in analysing the function of the reaction scheme as a narrative. What I want to stress is that a progression in time still underlies this kind of narrative, if only in an implicit or latent form. We can see this in two different ways.

First, the reaction scheme is a thin 'narrative of nature', Paskins argues, in the sense that the actions of chemist-researchers have been flattened onto the plane of the molecules. If we 'thicken' the narrative by reintroducing elements of the research narrative, time re-enters the account explicitly as both ordering and duration, such as in the gloss provided by Pierre Laszlo: 'let this mixture return to room temperature (rt) over four hours' (quoted in Paskins, Chapter 13). By virtue of involving human agents, a research narrative will always have some basis in time – human actions are performed in time – and, as

³⁰ Sequence or order (*ordre*) is distinguished from duration (*durée*) in narratologist Gérard Genette's treatment of narrative temporality.

Meunier (Chapter 12) demonstrates, narratives of nature are often distilled out of accounts that begin by mixing human interventions and objects' reactions.

The above logic relies on re-inserting a human actor (or at least a living agent) into the narrative; it is an external logic of time-relatedness, if you will. My second proposal for understanding 'configurational' narratives as situated in time proceeds by invoking an internal transposition of the narrative.³¹ I like to think of this as similar to parameterizing the narrative in time, borrowing a term from my training as a physicist. Parameterizing is what mathematicians or physicists do when they take the movement of an object in space, like a ball thrown in an arc, and instead of writing equations showing how its vertical movement relates to its horizontal position, they break both down into how they rely on time. Time order and duration thus become explicit in the latter form, where time is only implicit in the former set of equations (vertical vs horizontal position) – the physicist chooses between them depending on what she wants to examine. Similarly, physical chemists might take a chemical reaction – expressed in the transformation-based (non-temporal) logic of the reaction scheme – and create a simulation that steps in time through the process by which molecules come together, exchange protons or create different bonds (as in Wise 2017). In other words, they might transpose the 'configurational' narrative into explicitly temporal steps – for instance to investigate which parts of a reaction occur most rapidly.³² An analogous transposition is described by seminal French narratologist Gérard Genette (1972: 78) when he compares the temporal extension of an oral narrative – the time taken to tell the story – to that of a written narrative: the written text has an extension in space (words on a page), which we can conceive metonymically as an extension in time, in terms of the time it would take to read the text.³³ Moreover, in any number of literary texts studied routinely by narrative scholars, there is a greater symbolic or semantic significance to other linkages than the temporal (Schmid 2013). Some scientific narratives have just as low a degree of narrativity – measured along the time dimension – as many of their literary counterparts studied by narratologists, and the inverse. My point, again, is that both narrative scholars and historians and philosophers can (and do) pose more fertile questions than definitional points about time-situatedness. Chapters in this volume demonstrate other, richer analyses of time in scientific narratives: whether chronologies take a relative or

³¹ This second form is thus more broadly applicable.

³² The situation examined by Wise (2017) is more complex than this because it is solving a different kind of puzzle, one involving quantum-level interactions. An inverse transposition (time to space) occurs in some of the spatial diagrams of the Tohoku earthquake (see Miyake, Chapter 5). Kranke (Chapter 10) also elucidates the ways phylogenetic tree diagrams can be constructed to emphasize time-progression through evolution, or, alternatively, to draw out relationships between species.

³³ The distinction here is in terms of the '*temps du récit*'. This notion is especially crucial when it comes to comparing the 'duration' (*durée*) of events in the story and in the discourse (or written narrative) (Genette 1972: 122–124).

absolute basis (Teather, Chapter 6), or the narrative implications of adopting a periodic temporal structure (Huss, Chapter 3).

2.2.3 *Narrative Closure and Narrative Levels*

The final element in my discussion of narrativity in scientific narratives is the question of closure, which falls under Ryan's (2007: 29) 'formal and pragmatic dimension' of narrativity. Narrative closure is a matter of a reader's reception of a text on a cognitive or affective level, and is usually held to occur when a reader's expectations of the story are met, or their questions answered (Klauk, Köppe and Weskott 2016). To the extent that scientists report completed research actions or propose answers to puzzles, scientific narratives tend to be constructed explicitly as closed (or alternatively as unambiguously open – when a puzzle remains unsolved). When twentieth-century palaeobiologists proposed to account for extinction events in the fossil record (Huss, Chapter 3), their narrative of how such mass extinctions are caused by periodic extraterrestrial events comes in itself to a closed ending: it answers the puzzle question of how and why extinctions occurred.

If the periodic narrative itself, along with most scientific narratives, achieves closure in the basic sense of providing an answer, the concept remains worthy of note in narrative science for pointing to the imbrication of several narrative levels in scientific knowledge-making. Narrative closure is perhaps always a matter of multiple levels, as an individual reader's affective 'sense of an ending' is informed by that reader's cultural expectations (see Klauk, Köppe and Weskott 2016). In the case of scientific narratives, this multi-level nature of closure is additionally linked to the nature of the scientific enterprise, under which knowledge must be validated by the scholarly community. John Huss (Chapter 3) teases out these intertwined narratives with regard to the periodic extinction story. It was not sufficient for the palaeobiologists to propose this new periodic narrative as explanation; while it offered a closed answer to their question, the palaeobiologists were also impelled to search for evidence to support its claims.

On the individual level, we can consider this search as palaeobiologists' striving to reach an affective sense of properly 'scientific' completeness, in accordance with prevailing scholarly virtues and community standards for knowledge: the extraterrestrial story had to be 'filled in' with a certain level of artefactual evidence, however plausibly it accounted for mass extinctions. The palaeobiologists' search for evidence also arguably constituted a pursuit of narrative closure on the level of the story of their discipline.³⁴ Joseph Rouse (1990) terms this level one of narratives 'in construction', in the sense that

³⁴ Other levels can sit intermediate between these two, as Hopkins details (Chapter 4): alongside particular accounts of the formation of the Stac Fada Member, and a sense of progress in their field, geologists invoke broad (uniformitarian) narratives about the earth.

actors in a field of enquiry conceive of its past and future trajectory in narrative terms, and subscribe to a shared view that knowledge proceeds by seeking evidence for hypotheses and remaining open to revising past accounts.³⁵ Scientific activity, then, interweaves this shared, always open-ended narrative (of science, of a discipline) with the various closed and coherent narratives developed by scientists about their objects of study; it comprises ‘an ongoing tension between narrative coherence and its threatened unravelling’, in Rouse’s terms (1990: 183).³⁶ Examining the narrative condition of closure thus brings into prominence the necessary interweaving of the *social* in scientific activity (through narratives of a field, or expectations about epistemic virtues) and *particular* scientific narrative-making by scientists. What remains to be elucidated is quite what might demarcate closure of a scientific narrative in the proper sense, linked as it is to scientists’ *affective* responses, from the more general tenets of scientific enquiry as it develops through time. For it is far from clear that we should follow Rouse in considering all scientific activity as a narrative in progress – that would be to turn away from our narrower conception of narrative in the NS Approach. Exploring the affective dimension of scientific narratives – why, for instance, some seem more ‘elegant’ or appealing – indeed comprises a vital next step in the study of narrative science. Elspeth Jajdelska’s contribution to this collection (Chapter 18) makes a start, and points the way towards the kind of collaboration between cognitive science, narrative scholarship and HPS that is needed for careful work on these borders between the formal, the affective and the social.

2.3 Formal Matters

2.3.1 *Story/Discourse*

Thus far, I have been using the rather unwieldy term ‘narrative’ – as noun, as adjective – in relation to conditions on narrativity. One of the fundamental tenets of narratology, however, provides us with the possibility of bypassing the multivalent ‘narrative’ (especially as we use it in English), and delineating different levels of narrative as at once both act and representation. Narratologists conceive narrative as a dynamic relation between a *story* – the events which are recounted – and a *discourse* – the way those events are

³⁵ See also Borelli (2020: 435). We might also apply this notion to the narratives that synthetic biologists construct of their field, or that mathematicians employ to explain different programming architectures (see Berry, Chapter 16, and Dick, Chapter 15, respectively).

³⁶ See also Levine’s (2015: 40–42) account of narrative closure in novels as nonetheless ‘organiz[ing] relationships into the future’. Both Rouse’s and Levine’s analyses have explicit political aims. Meunier (Chapter 12) examines precisely the way experimental research articles both close one research episode and open onto new questions for the field.

recounted.³⁷ Faced with a given narrative, we only have immediate access to the discourse, that is, to the text of the document. Let us assume that we have a fixed set of events to relate, such as the sequence of actions needed to isolate a biochemical substance.³⁸ We could represent those events in discourse in many different ways. For example, the story of how to synthesize tropinone could be written as a chemical reaction scheme or written in words; it might include essentially no information about the chemist's actions, or it might add in those actions and their historical context; it could pass quickly over certain steps and linger when telling others. The distinction Paskins draws (Chapter 13) between thin and thick chemical narratives therefore also emerges out of considering how much information, and of what kind, is contained in different discursive versions of a single chemical synthesis story.³⁹ Using terms from narrative theory adds rigour to such investigations, because we can precisely label different domains of narrative structure.

To dissect a scientific narrative into story and discourse also draws our attention to potential mismatches in the order and duration of events recounted, which in turn means we can unpack the temporal dynamics of the narrative in detail. Many scholars have noted, for instance, that scientists do not necessarily recount experiments in the same order in which they performed them in the lab (see Meunier, Chapter 12).⁴⁰ Narrative theorists like Gérard Genette (1972) have given us not only the story–discourse pair (*histoire–récit*, for Genette), but also a precise, neutral terminology for designating different temporal orderings and durations.⁴¹ As yet, detailed analysis of the temporal workings of scientific documents remains another area to be filled in by further NS studies: for example, how might differing order and pacing (between story and discourse) be used to persuade readers, generate suspense or achieve closure? Here, I develop only several possible strands of this temporal analysis.

We know from the work of scholars like Genette (1972: esp. 78–80) that it is rare in literature for the ordering of events in the story to coincide directly with that of events as recounted in discourse. Fairy tales are perhaps one exception (Puckett 2016: 184–185). In science, short narratives of nature also tend to have the ordering of story and discourse coincide – look at examples quoted at the

³⁷ Story and discourse are the most common terms, though some narratologists employ other labels.

³⁸ For example, a substance in the fruit fly (Meunier, Chapter 12), or glycogen as isolated by Claude Bernard (see Hajek's case in *Anthology II*).

³⁹ See also Kranke (Chapter 10) on different representations of a single 'underlying' phylogenetic tree diagram.

⁴⁰ Meunier's analysis is more complex than my discussion of his chapter here, as he introduces a third domain into the narratological framework, and distinguishes the 'practice-world' from the story and the discourse.

⁴¹ I will introduce some of Genette's terms in notes and asides here, without presenting a complete overview of his scheme.

beginning of Meunier's and Miyake's chapters (Chapters 12 and 5). More intriguing is the kind of temporal dynamic required cognitively and epistemically by historical sciences like evolutionary biology. Sharon Crasnow groups these kinds of scientific endeavours under the framework of 'process tracing' in her *Interlude* (Chapter 11) and elucidates their shared reliance on forms of evidence that intermix time and causality. These are phenomena best construed by following the effect of certain causal factors through time, through a process; what does this entail for the relative temporality of their story and discourse?

Let us take John Beatty's example (Chapter 20) of the evolution of flatfish. The narrative constructed by a biologist to explain this evolution might begin with the observation that flatfish have their eyes offset on their heads – that is, the discourse begins with an observation, which is the end event of the story of how flatfish came to have the features they do. (For the investigating biologist, it is likely a middle-term event.) The discourse would then usually jump backwards to the selected starting point of the evolutionary story – i.e., a moment when flatfish swam upright and had eyes located symmetrically on their head.⁴² But, after this initial jump, for a biologist to provide a properly Darwinian account of the flatfish's evolution, they must ensure that the story unfolds each of the incremental steps in time order, leading from the fish's initial form to its form with offset eyes (Beatty, Chapter 20). Such a story is narrative worthy, according to Beatty (also 2016) precisely because of its contingency. Potential evolutionary 'branches-not-taken' might appear implicitly, embedded in the narrative,⁴³ but there would not be the kind of jumps backwards (or forward) in time to new sets of events that we see in a novel like *Frankenstein*, or a classic Freudian psychoanalytic case.⁴⁴ The discourse also compresses millions of years of incremental changes (in story time) into a narrative tellable in human timescales.

The epistemic conditions on such a (Darwinian) historical account require a careful temporal unfolding on the level of the *story* of evolution; by implication, we would expect this to be reflected in the *discourse*. That is, we would expect the coincidence in timing between *story* and *reasoning* about the fish's evolution to mean events must follow in sequence when scientists put such a story into narrative (the discourse), such that the crucial time-ordering of events could be conveyed to the reader. Curiously, analogous examples in this volume suggest that this is not the case. Hopkins (Chapter 4) demonstrates that geologists write very few narrative discourses into their research articles about temporally unfolding geological transformations. Similarly, political scientists

⁴² In Genette's terms, this jump is an 'analepsis'. Although I concentrate on ordering in time here, duration is equally as important in Genette's narrative theory.

⁴³ See Ryan (1986) on 'embedded narratives'.

⁴⁴ I'm thinking here particularly of the case of Anna O . . . (actually written by Breuer), which has been subject to much scholarly analysis of the timing of events (see, for example, Skues 2006).

trace along processual pathways to examine, for example, whether the United States would have entered the Iraq War even had G. W. Bush not been elected president – yet their publications do not recount those processes in order from beginning to end.⁴⁵ Such a choice not to have scientific discourse recount events in their story order seems surprising. To use a frequent analogy between narratives in historical sciences and classic detective stories, it is as though Holmes never unveiled his solution to Watson, but left the reconstruction of steps in the murder to the reader. For now, I can only raise the question; it must be left to further narratological investigation to ascertain the dynamics of ordering and duration in such scientific narratives.

2.3.2 *Narration and Focalization*

Beyond a careful attention to relative timings, classic narratology also directs us to interrogate whose perspective is expressed and with what authority, at each of the story and discourse levels. It is here that we can most clearly mark the ways narrative – especially in extended, verbal format – is a complex, formal edifice, however ‘natural’ it might often appear.⁴⁶ Narrative theorists differentiate first between the *author* of a work and its *narrator*: the author (e.g., Mary Shelley) writes down (or draws, etc.) the narrative, while the narrator tells the story (e.g., Victor Frankenstein). Although author and narrator are often presumed to be one and the same in non-fictional (‘factual’) narratives, Robert Meunier (Chapter 12) argues cogently that we should consider them as separate entities, especially for multi-authored scientific texts. Having posited that distinction, what interests me here are the *narrators*, the tellers from whose point of view we receive some narrative element: whether they appear as a character in the story, and how directly they reveal their perspective. In a pure narrative of nature, for instance, the narrator tells the story, but is not a character in it; the perspective is an external one, and appears impersonal, as in the quotation which opens Chapter 5. Historians of science will be used to contrasting such an impersonal narrator with the strong, self-fashioned narrative voice typical of eighteenth-century natural science (e.g., Terrall 2017). Such an early natural-scientist narrator is also a character in his story, and often relates his actions and emotional responses in the first person.⁴⁷ But there are more than these two

⁴⁵ This point emerged during Crasnow’s contribution to the NS Public Seminar Series (www.narrative-science.org/events-narrative-science-project-public-seminar-series.html). See also the importance of interview ‘data’ for the El Salvador civil war case (Crasnow, Chapter 11).

⁴⁶ Here I complicate Wise’s (Chapter 22) opposition of ‘formal’ and ‘natural’ language as a framework for envisaging narrative science, and his implicit privileging of ‘narratives of nature’ as the instantiation of scientific narrative.

⁴⁷ In Genette’s terms, the first narrator is both *heterodiegetic* (not a character) and *extradiegetic* (external perspective), while the second is *homodiegetic* and *intradiegetic* (Genette 1972: chaps. 4–5).

options present in scientific narratives, and that is precisely where using narratological tools reveals complexities we might not otherwise grasp.

We notably encounter more than one internal perspective in accounts from the human sciences, when the aim is to gain access to a human subject's mental, cognitive or emotional state.⁴⁸ Such interior views can be accessed and portrayed in a variety of different ways. In the following extract, from an experiment involving hypnotic suggestion, there is a shift in the *focus* of the narrative – it begins with the narrator–experimenters' point of view,⁴⁹ then shifts subtly to that of the hypnotized subject.

We take another coat and we pass it to M. F. . . , who puts it on; the subject, who gazes fixedly at this coat with a wondering look, sees it wave about in the air and take the form of a person. 'It is, she says, like a mannequin with nothing inside it.' (Binet and Féré 1887: 229)⁵⁰

The hypnotic suggestion in question is that Monsieur F. will be invisible to the subject. As the extract begins, we see the narrator also present as character(s) in the story, performing actions with the coat, and then observing the subject's reaction. This reaction first consists of external features of the subject – her 'wondering look' – described from the narrator's perspective, before the text moves to portray what the subject sees, and then relate the subject's words about her vision. Throughout, the telling is done by the narrator–experimenters; they refer to the subject in the third person. But the narrative also relates information to which, logically, the narrator–experimenters do not have access, in the form of the subject's interior view; there is a shift in who 'sits behind' the words of the text, with the narrator–experimenters and the subject 'doubling up' for this part. This is an example of shifting narrative *focalization*.⁵¹

What I want to emphasize are the kinds of questions we can ask after noticing such a shift (or, more often, repeated shifts) in focalization in a narrative. On the one hand, the subject's perspective is stamped here with the authority of the narrator as (a pair of) scientists. The description of what the subject sees is an interpretation, based on or validated by the subject's words (which are also

⁴⁸ Thinking back to Ryan's (2007) conditions of narrativity, we have a 'mental dimension' here for both scientist (narrator/character) and subject (character).

⁴⁹ For this limited analysis, I set aside the complexities of the plural nature of the narrator and treat it as a single entity encompassing two experimenters.

⁵⁰ My translation. I analyse this passage in greater detail in Hajek (2016a).

⁵¹ With shifting focalization also comes narrative polyphony, a multi-vocality present in the background to Bhattacharyya's paper (Chapter 8). Scientific polyphony was also the topic of a NS workshop, 3 June 2019 (www.narrative-science.org/events-narrative-science-project-workshops.html).

reported). On the other hand, noticing the shift in perspective – and that it occurs *before* the subject speaks – draws our attention, as readers, to the representational surface of the text – to the fact that it is *a* presentation of the story, and that there might be others. There is notably a small temporal mismatch here, since the narrator–experimenters’ interpretation, which occurs first in the *discourse*, must logically follow the subject’s speech on the level of the *story*. We are reminded that the immediacy of this experimental report is constructed, that writing occurred after the activity of the experiment. Did, therefore, the subject say exactly what is reported, or are the words (also) a reconstruction by the narrator–experimenters to validate their interpretation? More fundamentally, when did knowledge-making occur here – during actions, or during writing, or both? I would stress that it cannot be fixed down; narrative, (even) in its textual form, is not only an output of scientific activity, but fully and necessarily participates in the activity of knowledge-making. This is narrative as ‘the expansion of a verb’ (Genette 1972: 75), or the binding together of ‘narrativizing’ and ‘narrative representation’, in Morgan’s terms (Chapter 1).

If, in a sense, this brings us back to the kind of arguments well known in history of science under the label of ‘constructivism’ (e.g., Golinski 2005), it does so from the distinct perspective of narrative. Formal narrative analysis can do more than signal that knowledge emerges from putting scientific activity into words. It can suggest different patterns of authority in narratives from sciences which study humans, compared to those which do not. My brief analysis above, for instance, points to the ways that shifting narrative focalization seems essential to the business of the human sciences around the turn of the twentieth century, but also to a concomitant trade-off in the form of a more unstable textual authority. Further work could study how textual dynamics of this kind articulate with scientists’ avowed theoretical orientations; for example, do behaviourist psychologists, who eschew internalized observations, nonetheless produce focalized narratives? How do these dynamics compare with narrative focalization in accounts involving anthropomorphized (non-human) protagonists, on the one hand, or multiple interacting humans, on the other hand (as in social sciences like anthropology)? Curiously, there is narrative focalization on plant growth at multiple narrative levels in the Darwins’ *Power of Movement in Plants* – not only when the Darwins narrate their story, but also when the plants themselves are (co-)narrators, as Devin Griffiths’s narratological reading reveals (Chapter 7).⁵²

⁵² Griffiths further explores the implications and constraints of such non-human co-narration on genre and on narrative level (see Chapter 7, esp. Table 7.1).

2.3.3 Which Comes First?

Analysing shifts in narrator focalization prompted me to ask whether Binet and Féré's subject spoke the exact words related, or whether the experimenters filled in a plausible comment while writing their text. In story-discourse terms, this is equivalent to asking whether Binet and Féré's text – as discourse – reports a pre-existing *story* and just reorders the events, or, alternatively, whether portions of the story are only constructed (and re-constructable) through their inclusion in the *discourse*. As Kent Puckett (2016: 35) asks: 'Do events precede their representation, or does a representation somehow *produce* events as significant and thus knowable?' This 'paradox' (Puckett 2016: 215) points to a central tension in narrative theory over which of story or discourse comes first; it has been a productive force structuring the work of key narrative theorists, as Puckett sees it. NS studies also provide a particularly rich site through which to trace the dynamics of this tension, with conclusions that can feed back into theoretical work on narrative.

I am not advancing some radical constructivist view here, as if there were no reality outside of that which is '*mise en récit*' in a narrative. But, when it comes to scientific narratives, it is not always straightforward to identify what counts as story, as against the discourse, especially when we are dealing with non-human, non-anthropomorphized protagonists. Hence the richness of scientific narrative. Indeed, Meunier (Chapter 12) enunciates how both discourse and story (as events and their ordering implied in discourse) can differ from the events that took place in the experimenter's laboratory in 'reality', or the 'practice-world', as Meunier terms it – and this even for actions performed by and recorded by humans. When an archaeologist finds many Neolithic stone axes at some site, these can, on the one hand, serve as evidence or markers of story events – through some absolute dating method, for instance. On the other hand, the archaeologist might construct a narrative about popular stone quarrying sites, which might frame the axe find as a trace in a story about demand for felling trees.⁵³ Either way, story and discourse sit in a dynamic relation within the activity of scientific narrative-making.

The interplay of story and discourse is particularly clear in those scientific endeavours where narrative is not an end point, but where discourse-making and story-reconstruction occur iteratively.⁵⁴ In this volume, Teru Miyake's study (Chapter 5) of seismological work on the Tohoku earthquake is a salient example. Miyake's seismologists first take evidence from a single

⁵³ These examples are loosely adapted from Anne Teather's paper (Chapter 6).

⁵⁴ As noted previously, what I understand as necessarily interdependent, Morgan separates into functions of 'narrativizing' (to make the representation), 'narrative reasoning' (thinking from a narrative – closest to my discourse-making), and 'narrative explanation' (thinking within a narrative – like my story-reconstruction).

kind of sensor and configure it computationally into a time-stepped narrative simulation of how events in the earthquake occurred: the *rupture narrative*. Many rupture narratives are generated (e.g., from different types of sensors), and then compared by seismologists, who next extract details which are present in several rupture narratives; these details are treated as story-level events. Finally, ‘these distilled details are strung together into a model-independent rupture narrative, which [Miyake] call[s] an *integrating narrative*’. In narratological terms, successive steps in this scientific work take each of story and discourse, respectively, as pre-existing. Rupture narratives are first configured from story points (i.e., the sensor data evidence), before a switch in perspective, which construes the discourse of the rupture narrative as a source from which to reconstruct and extract a different set of story elements (Miyake’s ‘distilled details’). The final step flips perspective yet again, back to the work of constructing a narrative discourse (the integrating narrative) from (the new set of) pre-selected story details. Morgan (2017; and this volume) speaks of ‘narrative inference’ as unravelling and reknitting sets of evidential or conceptual elements.

If these iterative steps are clearly separated in Miyake’s account, we could speculate that such dynamic work of narrative configuration and reconfiguration is in play in scientific activity more widely, especially where phenomena are not directly observable. For instance, Elizabeth Haines (Chapter 9) points to a doubled way of working within visual narratives, when she shows how ‘neither evidence collection nor explanatory accounts were prior’ in Hugh Hamshaw Thomas’s botanical and intelligence-gathering practices. Opening out from this NS work, we might ask further whether scientific narrative-making (and re-making) of this kind could serve as a useful model for broader processes of narrative-writing and narrative-reading.

2.4 Narrative Reasoning

For now, I turn to existing narratological understandings of reading practice and how they can illuminate scientific reasoning. No telling is without its implied or actual readers, and they too perform important work in narrative-making, in an interplay with the narrative as textual or visual material. In a sense, therefore, I move now from considering narrative as the dynamic relation between *story* and *discourse*, to considering an interconnecting relation between *discourse/narration* and *reader*. It is a move which brings us into the domain of cognitive narratology – a field that combines findings from psychology and artificial intelligence to explore relations between story-text and -language, on the one hand, and human memory, perception and affect, on the other.⁵⁵ Concepts from

⁵⁵ See Herman (1997) and Jahn (2010) for overviews.

cognitive narratology are well suited to tracing the kinds of processes occurring in a reader's mind (or imagination) as they read a scientific text or diagram; notably, narratological concepts point us towards elements of scientific reading practices that might well be compared to ways people read fictional texts.

I construe such cognitive processes under the banner of 'narrative reasoning': they comprise story-like imaginative constructions which scientific readers generate when reading a research article or examining visual evidence.⁵⁶ If the scientific text in question has a clear narrative discursive form, narrative reasoning in the mind may not differ greatly from the logic of the narrative on the page, or it might be inferred using more classical narratological tools (of the kind discussed in the previous section).⁵⁷ Narrative reasoning is more distinctive as a component in scientific activity when story-like imaginative work is prompted by apparently non-narrative scientific texts – texts with very low narrativity (to link back to my earlier discussion). An example I have already evoked is the 'implicit' or 'covert' narratives of historical sciences like geology, which Hopkins argues only unfold as narratives to an informed reader. To interrogate narrative reasoning under my NS Approach is to examine the processes by which a scientist imaginatively replays such narratives, and, importantly, how these processes map onto particular textual elements. This explicitly adds a textual dimension to the narrative thought processes opened up by Morgan (Chapter 1). We might refer to tacit knowledge, scientists' trained judgement, or their horizon of expectations – to invoke some concepts current in HPS and narrative studies. However important, these are not enough for rigorous narrative enquiry, since they operate on a more general level: they relate texts as a whole to broad-scale expectations or knowledge in a field. With the NS Approach, we can delve into the specifics of which particular elements in a research paper or diagram activate story-like imaginative responses, as opposed to other cognitive functions. Notions like *narrative performativity* and *scripts* allow contributors to this volume to begin this work.⁵⁸ I briefly outline their findings in what follows.

As Elspeth Jajdelska emphasizes in Chapter 18, the question of who narrates a story and in what circumstances matters for its reception. Jajdelska transfers the notion of *narrative performativity* from the spoken to the written domain and, in a recursive move, elucidates its workings in a research article about cognitive science. Performative language is what early narratologists might have called properly literary language, in that it draws attention precisely to its

⁵⁶ This differs from Morgan's use of 'narrative reasoning' to describe reasoning *from* or *within* (pre-existing) narrative representations (Chapter 1).

⁵⁷ Meunier draws precisely these kind of interpretations in Chapter 12. See also Ryan (1986).

⁵⁸ Nina Kranke (Chapter 10) also connects elements of scientific documents – in her case, visual diagrams – to the narratives that readers construct from them, though without using particular narratological ideas.

aesthetic qualities. It thus bears a greater affective force and implicitly cues a certain imaginative worldview. The worldview thus rendered can encode assumptions or perspectives which support a researcher's explicit argumentative position, as in the article analysed by Jajdelska. Importantly, under this framework, particular textual passages, or even a few words, can be identified as corresponding to a story-like cognitive effect – one which plays a highly significant role in the knowledge claims of this scientific article.

A different kind of small-scale textual (or visual) element that produces story-like reading is the *script* (Herman 1997). In her chapter examining how mathematicians read proofs, Line Andersen deploys this concept from early cognitive narratology to argue that mathematicians read proofs similarly to how people read fictional narratives. That is, portions of the proof call up a sequence of events or actions that are expected or appropriate in the context in question. These proof-segments operate, in other words, like the scripts in literary texts for events such as 'eating in a restaurant, riding a bus, watching and playing a football game, participating in a birthday party, and so on'. As the AI researchers who developed the notion go on to say, 'These scripts are responsible for filling in the obvious information that has been left out of a story. Of course, it is obvious only to those understanders who actually know and can use the script' (Schank and Abelson 1977: 41).⁵⁹ Andersen develops the correspondences between script-activating elements of a proof and steps in mathematical understanding. Like readers of novels, the mathematical reader performs the mental action of running through steps cued by a script, but since scripts deal with expected sequences of actions, the reader's attention is particularly caught when a proof deviates from the expected background of mathematical scripts. By undertaking such narrative reasoning, mathematicians are prompted to focus on the novel, likely crucial, elements of a proof. Reciprocally, HPS analysts like Andersen can identify more precisely which elements count as most significant in mathematical reasoning and understanding, and for which kind of readers, since script-activation depends on a reader's level of understanding of an expected situation. Notions such as scripts, narrative performativity and other ideas from cognitive narratology could similarly be applied to many domains studied by HPS scholars. Wise, for instance, broadens the notion of script to several areas of scientific knowing in his *Finale* to this collection (Chapter 22). But where such an approach might bear most fruit is in combined textual and ethnographic analysis, of the kind sketched by Andersen – specific elements of a scientific text can be connected to particular narrative-like reasoning, and that mapping contrasted with scientists' own accounts, as well as analysts' reconstructions, of scientific activity.

⁵⁹ I thank Line Andersen for drawing my attention to this quotation. Morgan also signals the communal aspect of scientific narrative in Chapter 1.

2.5 Conclusion

Narrative theory is an extensive and complex field and, in this chapter, I have only worked through some of its key concerns and ideas as they apply to scientific narratives. My aim in doing so has been twofold. On the one hand, I have sought to encourage HPS scholars to treat narrative in the focused, technical terms of narratology, by demonstrating the analytical productivity this promotes. Such analysis – as undertaken in the NS Project and chapters in this volume – reveals that a ‘*mise en récit*’ always involves an active component of knowledge-making or reasoning, even when a narrative (representation) is also the output of some scientific endeavour. Reciprocally, if narrative in science is always active, it is not an activity divorced from any concrete, material basis; a major part of the value of narratological tools is that they can serve to trace precise connections between narrative as *text* and narrative as mode of *reasoning*. What the NS Approach provides, then, is precision and rigour to an object of study – narrative – that otherwise risks overflowing its conceptual bounds to such an extent as to offer no meaningful basis for comparison or interpretation. NS offers exciting perspectives as an approach deployed alongside the usual epistemic resources of HPS.

On the other hand, this chapter elucidates the various ways in which work in the NS Project is informed by concepts from narratology, even where such concepts are not emphasized or delineated. As historians and philosophers of science, contributors to this volume bring a sensitivity to the theoretical and contextual constellations in which their case studies can be situated. Our studies thus bring a depth of detail to explorations of narrative in a non-literary domain – they can complement and complete narratologists’ investigations in this area with much-needed science-specific expertise. Just as I hope future HPS work will be open to narratological perspectives, I similarly encourage narrative scholars to draw upon HPS expertise, as showcased in this volume, in developing their field beyond the literary. This chapter has notably pointed to some distinctive characteristics of scientific narratives – their frequent non-human, even generic, protagonists; their iterations of story-making and discourse-configuration – as well as proposing that there is less of a divide between scientific and literary narratives than often assumed, when it comes to their situatedness in time – it is just that different questions of timing might arise. And, of course, there remain many areas of enquiry where collaboration between HPS and narrative studies would be fruitful: the affective charge of scientific narratives, forms of narrative focalization and the particular interplay of ordering and duration in work in the historical sciences, to mention just some I have signalled above.

But to conclude this chapter I would like to turn briefly to the ambitions held by narratology to be considered a science, from its pre-history in Russian formalism to its more recent cognitive turn.⁶⁰ Could we apply the NS Approach to narratology itself? As Puckett (2016) stresses, narratology as a domain of enquiry is not without its own history. Where he historicizes it in terms of key political and intellectual currents, we might ask how narratology is informed by other scientific fields and what role narrative-making plays in its endeavours. If we had to classify narratology, we could place it in the category of the human or social sciences, as taking a human product – narrative – and its cultural and social imbrications, as its object of study. We might then sketch a shift in perspective from a view of narratology influenced by the model of chemistry – with stories dissected into a fixed set of re-combinable elements – to one that enacts something of a convergence with cognitive science and some branches of psychology. Early structuralist Algirdas Greimas (1983: 65), for instance, praised the language of chemistry as ‘a semiotic form which must, across all kinds of language, serve to express its meaning’,⁶¹ while to read Manfred Jahn’s encyclopaedia entry (2010) on cognitive narratology is to be plunged into considerations of ‘preference rules and processing strategies’ that would not appear out of place in a research article in computational science. By analogy with chapters in this volume, we might speculate that early structuralist narratology mobilizes ‘thin narratives’ of the kind identified by Paskins (Chapter 13), or that recent cognitive theories enlist strategies of ‘narrative performativity’ to provide imaginative support for their claims (as in the article investigated by Jajdelska in Chapter 18). What might such a transition imply for understanding the evolution or limits of narratology as a ‘historically specific logic’, to use Puckett’s terms (2016)? When we apply a notion like the *script* to a scientific narrative, to what extent do we invoke distinctively narratological theorizing, as against ideas from the script’s origins in AI? Or, is to pose such questions to descend into a methodological spiral, where narrative and science turn circularly around each other?⁶²

⁶⁰ The term ‘narratology’ dates from 1969, when it was coined by Tzvetan Todorov (Puckett 2016: 234 n. 23).

⁶¹ I thank Mat Paskins for suggesting this quotation.

⁶² Many thanks to Mary Morgan, Mat Paskins, Martina King, Devin Griffiths and John P. Hajek for insightful comments and suggestions on drafts of this chapter. Working with the Narrative Science core team – Mary, Dominic, Andrew, Mat, Robert – over the last few years has been a stimulating and enriching experience, for which I thank you all. Finally, I am ever grateful to Gordon P. Jardine for promoting my interest in language, narrative and their surprising turns; I dedicate this chapter to his memory. *Narrative Science* book: This project has received funding from the European Research Council under the European Union’s Horizon 2020 research and innovation programme (grant agreement No. 694732). www.narrative-science.org/.

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