I

Prologues

1 Narrative: A General-Purpose Technology for Science

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Abstract
Narrative is ubiquitous in the sciences. Whilst it might be hidden, evident only from its traces, it can be found regularly in scientists' accounts of their research, and of the natural, human and social worlds they study. Investigating the functions of narrative, it becomes clear that narrative-making provides scientists with a means of making sense of the materials in their field, that narrative provides a means of representing that knowledge and that narrative may even provide the site for scientific reasoning and knowledge claims. Narrative emerges as a 'general-purpose technology', used in many different forms in different sites of science, enabling scientists to figure out and to express their scientific knowledge. Understanding scientists' use of narrative in this way suggests that narrative functions as a bridge between the interventionist practices of science and the knowledge gained from those practices.

1.1 Introduction

Scholars of scientific life see it filled with experiments, models, theories, descriptions, observations, categories, etc. It is equally full of narratives. Yet

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the levels at which narratives work, and the kinds of things that scientists come to understand through the activities of developing their narratives, are not easily described in terms of any specific ambitions or functions. Narratives themselves may be understood as a broad class of 'epistemic genre', to use the label that Pomata (2014) developed, essential to the representation of scientific knowledge.[1] But narrative is more than just a means of representing such knowledge; rather, prior to such representations, narrative-making plays a wider role in the sciences as a means of sense-making. In contrast with Crombie's (1988) historically situated categorization of ways of doing science, an account developed further in Hacking's (1992) philosophical analysis, narrative-making is not mainly about how scientists investigate the world but rather about how they make sense out of those investigations. Narrative-making does not satisfy epistemic questions and worries in the way the interventionist and observational modes of doing science described by Hacking (and others) – such as experimenting, category making, statistical work and case-making – can do. Narrative-making and -using, by contrast, are more closely aligned with ontological questions, or, rather, scientists' claims in their 'narratives of nature' are ontological claims about the way the world is and works. The role of narratives piggybacks onto the epistemology of those other, more interventionist modes of practising science. So, while narrative usage may overlap in places with Pomata's notion of 'epistemic genres' and can be an accompaniment to Hacking's modes of doing science – narrative-making and -using fulfil other distinct roles for scientists, roles that need separate recognition.

Narrative emerges from this volume as having three functions for scientists: narrative-making operates as a means of making sense of their puzzling phenomena; it provides a means of representing that scientific knowledge; and it provides resources for reasoning about those phenomena. These three functions are related: it is because scientists often make sense of their world by making narratives that they then use those narratives to represent what they believe they know, and thence to reason with them. I propose we think of narrative as a 'technology of sense-making' that enables scientists to bridge between their interventionist activities of exploring the world and their knowledge claims about the world, that is, between their epistemic and

[1] Pomata (2014) labelled certain kinds of texts in science 'epistemic genres' in contrast with the genres recognized in literature. As she argued (in a historical account of changes in medical reporting), an epistemic genre: develops 'in tandem with scientific practices'; is 'deliberately cognitive in purpose'; is linked 'to the practice of knowledge-making'; and has a 'primary goal' of 'the production of knowledge'. These have certain parallels in the claims made in this chapter about the roles of narrative in science, but the functions I attribute to narrative-making have greater agency in *doing* science.

ontological realms. To label narrative a technology may seem rather strange, but we are in some interesting company here. The philosopher John Dewey argued that the notion of technology was not just about how to make things in the economy, but equally attributable to the abstract and intangible work of enquiry and deliberation involving cognitive work – just as we find for narrative in science.[2] His contemporary, the sociologist-economist Thorstein Veblen, insisted on the priority of the human element in designing, making and using a technology. While narrative-making, -using, and -reasoning start with the scientist and their community, it is worth remarking that narrative also embeds its own technical elements and attributes. These three separate but related functions of narrative, broadly understood as a technology of sense-making for scientists, may be recognized in the chapters of this book by observing whether narrative is being used as a noun, verb or adjective.

All those nouns of scientific practice – experiments, models, theories, descriptions, observations, categories – hide actions and activities: experimenting, modelling, theorizing, describing, observing, categorizing. Other elements that scientists use don't immediately convert between nouns and verbs – data has to be given its own multiple verbs ('to gather, clean, assemble and prepare'), just as laws have 'to be discovered or made'. Narrative is akin to laws and data: easily understood and effective as a noun, its scope as an activity is not quite so obvious; yet appreciating that scope is critical for understanding the broader role of narrative as a technology for scientists. The quintessential feature of narrative is that it shows how things relate together, so that constructing a narrative account in science involves figuring out how the elements of a phenomenon are related to each other. This is why narrative-making and -using are conceived here as a technology, one that enables scientists to make sense of their phenomena.

These basic usages of narrative in *noun* and *verb* forms are important, of course, but they might be still awkward, and limited, if we want to go one step further and conceive of narrative as flourishing in the knowledge-claiming activity of the sciences. In this respect, the adjectival form is more immediately useful: so, 'narrative account' and 'narrative description' might both be taken for granted. And, while 'narrative inference', 'narrative argument' and 'narrative explanation' might initially sound strange (even perhaps contradictory), it will turn out that we need these terms, for the narrative form does overlap in usage into these scientific activities of reasoning and knowledge-making. Thus, narrative as an *adjective* works as an attribute of a certain form of reasoning: giving a satisfactory narrative

[2] I thank Teru Miyake for drawing my attention to Dewey's insight, best followed in Hickman (2001).

account may go beyond sense-making into the kinds of reasoning associated with inference and explanation.

None of these uses of the term narrative – in noun, verb or adjectival forms – should be problematic if we can find ways to appreciate the active work that narrative does in our sciences, particularly if we can figure out its features and its functions, just as we have for data and laws. These grammatical labels give clues, but only clues, to the ways in which scientists develop, create and use narratives in their various fields, for various purposes and in conjunction with various other forms of scientific representation and knowledge-making activities. These language terminologies need to be filled in with examples and hardened through analyses to reveal the active work we attribute to narrative in science, and so to appreciate how narrative operates as a technology for scientists in doing science.

There are, of course, many commentaries about narrative in other domains, especially in the fields of literature, narratology and legal studies. Narrative scholars from the domain of literature typically focus on the narrative as text: its plots, its structure, temporal and spatial organization, its eventfulness and cognitive function, as well as its rhetorical and aesthetic components, and terms of affect. Narratologists tend to focus on the narrators, readers, what constructions narratives follow, and their requirements for narrative tellability. It is fair to say that with few notable exceptions, neither group focuses especially on connections of narrative with knowledge-making.[3] So, in an important chapter, Kim Hajek explores what is narrative about 'narrative science', and thus extends the relevant intersections of those fields with our agenda (Chapter 2). Discussions in the field of law about narrative range over matters of rhetoric and affect, but have an equal interest in the putting together of evidence, and the role of 'theory' – meaning both the hypothesis about what happened in a particular case, but also the concepts from law that need to be taken into account.[4] As such, these latter interests fit closest to those of this chapter. But rather than work comparatively with this legal literature I treat narrative in science on its own terms – in order to examine how it makes itself 'at home' in the scientific knowledge environment.

[3] Dear (1991) is a notable early work in the field (on which more later in section 1.6). Of four current books that overlap with our agenda to treat narrative in science seriously: Fludernik and Ryan (2020) attends to narratives in factual spheres (while our focus is on narratives in science, which are often, or not only, about 'facts'); Carrier, Mertens and Reinhardt (2021) are concerned with the contrasts and intersections of narratives and comparison in science; Dillon and Craig (2021) analyse how narrative can be used alongside scientific evidence in the public domain on account of the cognitive value of narratives; and Kindt and King (forthcoming) focus on narrative knowledge-making from a sample of ancient to modern texts.

[4] See, especially, Nicolson ((2019): chap. 7); Twining ((2002): chaps. 13–14); Twining ((2006): chaps. 9–13). Thanks to William Twining for introducing me to this literature and discussing it with me.

Narrative is a broad, expansive term (with many definitions in narrative theory), and the challenge has been to develop an analysis which is insightful for scientists' creation and use of narrative. Our research shows narrative to be an enabling, general-purpose technology, widely used by scientists within their own different communities to fulfil certain functions in their scientific work – even when they don't use the word or recognize that label for their activity. It is important to note the limits of this claim: narratives are not found in all aspects of all sciences. Rather, they fulfil certain kinds of function with some regularity in some sciences, or some sites of science, and in conjunction with some methods of doing science. By tracing this (sometimes hidden) narrative activity, and its locations, we can understand both what is different and what is generic in these usages in different sites, and so develop an understanding of narrative in the domains of science.

1.2 Narratives of the Field

The first challenge we address in this book is to see and locate the narratives that appear in our sciences. The most obvious narratives found in science may be those wrap-up accounts in publications resulting from the activities of scientists. In modern science, these are usually impersonal narratives,[5] cut down to the essential actions that scientists tell of how they went about their research: their 'research narratives'. Less recognizable, but still apparent, as Robert Meunier argues (Chapter 12), are their 'narratives of nature': the narratives – 'as if told' by natural, human and social life – that those scientists have tried to reveal, recover and make sensible. And, as he points out, scientists' research narratives often twine in symbiosis around their narratives of nature.[6] This has fruitful consequences: the researcher–author, in guiding the scientist–reader along the path of their activities, enables the latter to gain practical familiarity with the former's narratives of nature, particularly with any new elements and concept set in use.

A broader category of narratives can be found that seek to define and lay boundaries to new approaches for a whole field, or maybe to delineate a new interstitial field. These field-making narratives might be more or less reticent in their agenda. Grand ones are epitomized in the self-proclaimed narratives of those seeking to automate and computerize the whole of mathematics. Stephanie Dick (Chapter 15) discusses two such competing self-narratives in

[5] The significant exception is anthropology, where the scientist must be personally present in their narratives, and attend to the narrative text they create, to signal professional credibility (see entry on Geertz, *Anthology II*).

[6] These 'research narratives' and 'narratives of nature' are often openly related in medicine and management sciences, where scientists and their subject participants recount, and often share, their expert and experiential knowledge via narratives.

late twentieth-century American mathematics: one group sought to reformulate all mathematical knowledge into one single form, and the other to enable all mathematicians to contribute elements in their own format.[7] Their politics of control vs. pluralism were explicit. Other field narratives may be more opaque, evident only in their alignments and commitments, to be discovered by an outside reader, as Dominic Berry (Chapter 16) does in looking at how 'synthetic biologists' positioned themselves between engineering and biology in defining and growing their own field. He uses longue durée changes in history writing – from chronicles through genealogies to narratives – to argue his case. These are important categories. Chronicles report events solely based on their place in a time sequence without paying attention to any relationships between those events; *genealogies* focus on the 'family' (broadly construed) relationships between the events or objects; *narratives* provide an account of the relationships between events or objects (whether or not these relationships are tied together in a time sequence or by family connections). Among narratologists, there is a widespread view that a chronicle does not count as a proper narrative because the relational content is absent, while genealogies are just a subset form of narratives. Anne Teather (Chapter 6) adopts the same categories to show how new technologies of dating in archaeology have effectively changed narrative practices in that field. Whereas archaeologists used to tell *genealogical* accounts to frame the periods of prehistory (e.g., the Neolithic period), more recent technologies of investigation have created the more limited *chronologies* or *chronicles*.

Certainly, the narratives of nature – narratives of how the world is and how it works (whether it be the natural, human or social world) – are sometimes much harder to see than these research and field-making narratives. Narratives of nature are more likely to be found implicated with, or inside, other accounts of scientific activity. Like those sherds and trenches of Teather's archaeological sites, these traces of narrative point to the scientific activities that created them, and from which we must reconstruct the power that narrative-making and narrative-using have in such spheres.

1.3 Narrative: A Means of Scientific Representation

The core function of what narrative does is to bring and bind elements in a subject field together. Narrative-making in the sciences can be found in theorizing, in creating an adequate description of empirical materials or in marrying them to each other in ways that embed ideas and concepts,

[7] This chapter originated in our project workshop on narrative in mathematics. See workshop on mathematics on project website: www.narrative-science.org/events-narrative-science-project-workshops.html.

that is, in activities of sense-making and knowledge-making (examined in sections 1.4 and 1.5). Since the narratives that result from these activities express, or make evident, these connections between elements in a scientific domain, narratives can be treated as a form of scientific representation akin to other forms of representation. What are the characteristic aspects of such representations, and the implications of this way of understanding the role of narratives in science?

First, narrative representations found in science may appear as free-standing or separate pieces of verbal text – in ordinary or natural language. They might be embedded in visual representations (drawn into schemas such as diagrams of mechanisms or detailed representations of empirical matters in graphs), or even expressed in the completely formal languages of abstraction and mathematics. Wise (Chapter 22) contrasts the possibilities of natural and formal languages, and the extent to which they do different kinds of work, and say different things, and thus why narratives in the two forms are not simple translations or transpositions of each other. Depending on the science in question, the narrative form of representation will be more or less formalized, more or less abstract, and may have more or less dimensionality of elements compared to other representational forms of diagrams, equations and so forth. But, whatever their form and language, it is typically the case that they are 'community narratives', to be understood without further explanation or accompanying text only by those in the expert community who use them. Mat Paskins (Chapter 13) translates/explains, for us lay-readers, the 'chemese' of chemical reaction diagrams depicting the synthesis of particular molecules. He points out that early twentieth-century versions told a different narrative from early twenty-first-century versions of essentially the same representation: in early years, the 'equation' expressed the sequence of steps taken to synthesize a certain chemical, but in later years, such diagrams came to narrate the chemical reactions that took place. The 'cartoon' narrative shown in Andrew Hopkins's chapter (Chapter 4) relates what happens in a meteorite impact as material explodes, flows out and gradually builds up deposits on the ground. This requires, for the lay reader, a lengthy verbal narrative that lets us follow the combinations of interacting processes and outcomes from these geological events.[8] In other cases, indirect representations of nature (such as mathematical models) are manipulated to show the narratives implicit in visual schematic representations. We find such narratives in the computer visualizations from simulating snowflake growth and the processes of chemical reactions, as shown by Wise (2017); the latter offers an alternative free-standing, time-stepped,

[8] Another great example is found in Hopkins's analysis of three different geological diagrams depicting different theories and dimensions of the formation of the continents over long geological time (in *Anthology II*).

visualization of the chemical reaction 'equations' found in Paskins's paper (Chapter 13). Such narratives give clues to the density of knowledge that typically lies behind formal language representations.

Second, more often than free-standing independent forms, textual narratives are strongly co-dependent with other forms of scientific representation, such as charts, graphs, drawings, maps, matrices, models, formulae and so forth. Such textual narrative accompaniments might well be an essential part of the identity of those representations, whether of the evidential diagrams in graphs or of the theory-based representations found in models. The classic well-known example is Darwin's pictorial 'tree of life', which – when read alongside textual information – offers a shorthand depiction showing how evolving species branch, or die out, or survive. It is a kind of genealogy – but a conceptual tree not a report of observations. Greg Priest describes this as a 'scaffold' on which we as readers can stand to 'create narratives that enable us to understand' Darwin's account of natural evolution.[9] The infamous 'prisoner's dilemma' model from economics (which was soon transferred to other social-science and biological domains) consists of a mathematical matrix, a set of inequality conditions on those numbers, and a narrative text of the possible behaviours of the 'prisoners' given the 'dilemma' of their situation (termed by economists, 'the rules of the game'). The narrative is an essential element in identifying the game and differentiating it from others that may look similar, for the matrix and inequalities are both insufficient (see Morgan 2007). Combinations of text and drawings (keyed with numbers to each other) are found as essential partners in communicating narrative accounts of metamorphic changes in the insect world (from egg to caterpillar, larva to butterfly), as seen in Mary Terrall's (2017) discussion of eighteenth-century accounts of this phenomenon. Such matching media of visual and text narratives, in which neither is primary but each depends on the other, are also used to explore possibilities of hypothetical events as we see, for example, in D'Onofrio's account of eighteenth-century generals re-running historical battles according to geometrical lines (in *Anthology II*).

There is often a kind of bonding here, rather than co-dependency, of forms and functions. Narratives embedded in formal languages and visual representations often provide a highly efficient rendering of the materials of events. The phylogenetic trees of the evolution of the kangaroo and other marsupials discussed by Nina Kranke (Chapter 10) express a travel saga that charts their geographical and biological evolution over time and space as the species evolved while members of its ancestral population 'journeyed' from South America to Australia. As she shows us, such 'trees' exist in multiple formats – showing in succinct ways, but with distinctly different variants,

[9] See Priest's extract from Darwin, and his commentary, *Anthology II*.

the narratives of different kinds of family trees or genealogies. Some of these are for professional audiences, some for museums; some are plain, some 'filigreed'; some read upwards, some downwards, some sideways. There is no one convention despite the related kinds of narratives that are told by these related kinds of trees. There is surely a family tree of such trees, a genealogy of trees, going forward in evolutionary biology from Darwin's tree of life, and going back in time in a long tradition of drawing human dynastic trees.

This complementarity, and bonding, of narratives alongside and inside alternative representations show how narratives fulfil their representing functions in the sciences and how narratives do the kind of representing work they do. These kinds of co-dependency also suggest there are *no* strong reasons to privilege narratives as a text form when narratives can find their primary expression in other forms of representation. Narratives in the visual, schematic or even mathematical forms of representation may perform by *showing* as much as by *telling*; they are designed to be 'seen' by others in the same community of scientists who know how to 'read' them. For example, Martina Merz (2011) recounts how readers of a scientific paper in a particular field of physics will automatically follow the diagrams that are arranged in a clockwise fashion at the beginning of the paper – these 'show not tell' the research narrative of the salient activities, and readers follow that visual narrative before bothering to read the text of the paper. In some cases, nature's entities show their own narratives directly. Devin Griffiths (Chapter 7) tells how the Darwins set up plants so that their roots traced out their own growth narratives in scientific experiments. Starting from these visual autobiographies, Darwin constructed narratives at three different genre (i.e., generic) levels: 'micro-narratives' of individual plant life, the 'novella' of the life history of plants and the saga of biological evolution.

In sum, I argue two points: first, that narratives (like models, diagrams, equations, graphs, etc.) can be understood as a mode of representing scientific things (ideas, theories, processes, evidential records, relations, etc.); and second, that such narrative forms are quite likely to hybridize or be co-dependent with, or even entirely embedded within, those other media of scientific representation.

1.4 Narrativizing: A Means of Sense-Making

Narratives in science are not given by God, or by some other external authority, but designed and made by scientists in their research communities. Attention has to be given to the ways that they create narratives as a means of sense-making – to the active work of narrative formation in the practices of scientists, especially with respect to their narratives of nature.