

## 12 Research Narratives and Narratives of Nature in Scientific Articles: How Scientists Familiarize Their Communities with New Approaches and Epistemic Objects

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### **Abstract**

The chapters in this volume show that narrative can be found on many levels and in many media in science. This contribution locates narratives in one of the most prominent forms of scientific literature in the twentieth century: the research article. It shows how in the experimental sciences accounts of natural processes and accounts of research activities both take the form of narratives, ‘narratives of nature’ and ‘research narratives’, respectively. For a hypothesis to enter the former or to be criticized, members of a scientific community need to grasp the research approach from which it emerges. The chapter argues that research narratives are designed to make readers familiar with an approach. Such narratives draw a path through epistemic scenes inhabited by a character representing the researchers. By stylistic means the researchers are construed as exemplars for members of the community, and their activities as exemplifying the approach to a shared problem.

### **12.1 Research Narratives and Narratives of Nature**

In 1945, George Beadle, who was to receive the Nobel Prize in Physiology or Medicine in 1958, together with Edward Tatum, published a long review article on the state of biochemical genetics. In one section, entitled ‘Eye pigments in insects’, he summarized results stemming to a large extent from his own work, which he had initiated with Boris Ephrussi in 1935, preceding his collaboration with Tatum. Beadle and Ephrussi used the fruit fly *Drosophila melanogaster*, which at the time was already a well-established experimental organism. Their experiments, however, introduced a novel approach based on tissue transplants between flies carrying different combinations of mutations. The results of these and similar experiments, and further biochemical efforts to characterize the

substances involved, led to the following account of the physiological process of the formation of brown eye pigment and the roles of genes therein:

Dietary tryptophan is the fly's initial precursor of the two postulated hormones. This is converted to alpha-oxytryptophan through a reaction controlled by the vermilion gene. A further oxidation to kynurenine occurs. [...] This is the so-called  $v^+$  substance of Ephrussi and Beadle. This is still further oxidized to the  $cn^+$  substance, which Kikkawa believes to be the chromogen of the brown pigment. The transformation of kynurenine to  $cn^+$  substance is subject to the action of the normal allele of the cinnabar gene. (Beadle 1945: 34; references omitted)

This text constitutes a small narrative. It relates several events which occur in temporal order and are causally connected. The sequence has a beginning (the precursor is ingested), a middle (it is transformed in several reactions controlled by genes) and an end (the implied formation of brown pigment). Yet, this narrative does not recount particular events, but rather a type of event happening countless times in fruit flies (and similarly in many other insects); it is a generic narrative.<sup>1</sup>

In the natural sciences, such narratives are often found in review articles and textbooks, but also in summaries of the state of knowledge on a given subject in the introduction to research articles; they state what is taken as fact. Addressing scientific facts as narratives acknowledges that they are typically presented as complex and ordered accounts of a subject rather than single propositions. It is striking that no human agents, observers or cognizers are present in such narratives. They are accounts of events that are taken to happen 'in nature' when no researcher is intervening or even watching. Such narratives can thus be called 'narratives of nature'.<sup>2</sup>

Historians and philosophers of science no longer see the question of epistemology to be concerned with the truth of such knowledge claims alone, but also with the practices from which they emerge, and which enable, shape and delimit these claims. The references in Beadle's text make it clear that each proposition can be traced back to an episode of research. Narratives of nature emerge gradually from the research literature as facts accepted in a community. Accounts of the methods by which the knowledge was achieved are abandoned like ladders once the new state of knowledge is reached. The facts are turned into 'black boxes', which can, however, be reopened any time; methods are called into question when facts are challenged (Latour 1987).

To account for how a hypothesis derived from research eventually enters a 'narrative of nature', it is necessary to show how a hypothesis comes to be

<sup>1</sup> 'The world of the generic narrative [...] is not a unique world, but rather a class of worlds in which the activities and circumstances generally obtain. Any given event, agent, or object in a generic discourse actually stands for a class of such objects' (Polanyi 1982: 511).

<sup>2</sup> Myers (1990: 142) uses the expression in a related sense regarding popular science.

known and understood by members of a community in the first place. I will argue here that this requires peers to understand the research approach – which aligns a method and a problem, and in the context of which the hypothesis was formulated. Familiarization with the approach is achieved by using another type of narrative, realized primarily in research articles. The function of research articles is thus not only and primarily to convince readers that a hypothesis is supported by evidence, so that they will accept it.<sup>3</sup> Instead, by making readers familiar with the approach, the article enables them to understand how one gets in the position to formulate and support a hypothesis of this kind in the first place, its relevance regarding a problem recognized in the community, and the meaning of the terms used (i.e., to grasp the epistemic objects in question).<sup>4</sup>

An approach is a movement, it involves positioning oneself towards a phenomenon and accessing it from a particular direction and in a particular way.<sup>5</sup> The phenomenon, the experimental system employed for accessing it, the activities of intervention and observation afforded by the system, and the ways to make inferences from observations, including the recognition of invisible entities, make up what I call the ‘practice-world’ of researchers. The research article introduces the reader to this world and to the way that researchers position themselves by interpreting a problem pertaining to a phenomenon, to access the phenomenon, materially and cognitively, generate data and draw inference – in other words it makes the reader familiar with an approach. Only then can the hypothesis be understood; but it does not need to be accepted. Any criticism, refinement or amendment of the hypothesis is articulated in terms that are meaningful in the context of the approach and often involve the recreation of the approach by members of the community, introducing more or less substantial variation.<sup>6</sup>

In this chapter, I will show how research articles employ narrative to familiarize readers with an approach. Reporting the material (intervention and observation) and cognitive (inference) activities of researchers, research

<sup>3</sup> Crasnow (Chapter 11) argues for narrative processes as making evidence from data. Jajdelska (Chapter 18) explores an alternative means of familiarization in research articles, by means of narrative performativity.

<sup>4</sup> According to Rheinberger, experimental systems “‘contain” the scientific objects in the double sense of this expression: they embed them, and through that very embracement, they restrict and constrain them”, and thereby ‘determine the realm of possible representations of an epistemic thing’ (1997: 29). Approaches in the experimental sciences involve experimental systems, yet the notion is broader, referring to the ways an experimental system is used to address a problem and its output is interpreted.

<sup>5</sup> On a related notion of ‘approach’, see Waters (2004). On my account an approach is the equivalent for practice of what philosophers refer to as perspective regarding theoretical representation (e.g., Giere 2006).

<sup>6</sup> For experimental systems this has been referred to as ‘differential reproduction’ (Rheinberger 1997).

articles on the whole are narratives (even if they often contain non-narrative passages) and might be referred to as ‘research narratives’. Like narratives of nature, research narratives are factual narratives, but in contrast to the former, they recount particular events, which happened at a specific site (e.g., a given laboratory) and a specific time; they are not generic. And yet, as will become clear, they do not present these events as unique either, but rather as exemplary.

In section 12.2, I will introduce several narratological concepts pertinent to the analysis. In 12.3, I will then trace back some of the elements of the narrative of nature above to an original research article by Beadle and Ephrussi, which I take to be representative of this genre in twentieth-century experimental life sciences. Section 12.4 will then return to the ways in which the particular implementation of an approach is rendered exemplary.<sup>7</sup>

## 12.2 Research Articles as Factual Narratives

Subsection 12.2.1 will argue that modern research articles are indeed narrative texts. As they are generally taken to be factual narratives, I will briefly address the question of how they relate to real-world events. Subsection 12.2.2 will clarify the relation of researchers in their double role as agents and authors, and as narrator and character. It will then relate these roles to the narratee and the implied and actual reader. I will also introduce two metaphors: narrative as path and narrating as guidance, to further characterize the relation of narrator and narratee.

### 12.2.1 Research Articles are Factual Narratives

When talking about narrative, one often thinks of fictional texts or accounts of personal experience.<sup>8</sup> Research articles might not meet common expectations about what a narrative is. Nonetheless, research articles should be seen as narratives. Before showing why, I will address some ways in which they depart from more typical narrative texts.

First, research articles have a unique structure in that they typically separate the accounts of various aspects of the same events. This partitioning of information is often realized in the canonical ‘introduction, methods, results and discussion’ (IMRaD) structure.<sup>9</sup> In the *Introduction*, researchers state where they see themselves standing in relation to various disciplines and theoretical

<sup>7</sup> Philosophers of science, like scientists, aim to make not only their case but also their approach (here a narratological approach) familiar and exemplary, such that the insights derived from it can be discussed and the categories employed be transferred to other cases (see, for example, Currie 2015).

<sup>8</sup> On the latter, see Hurwitz (Chapter 17).

<sup>9</sup> On the origin of the IMRaD structure, see Day (1989).

commitments, thereby positioning themselves towards a problem recognized in the community they address and motivating the activities to be narrated. The detailed description of the activities, including preparation, intervention and observation, is presented in the *Material and Methods* section collectively for all experimental events. The structured performance of these activities is reported in the *Results* section, albeit not necessarily according to their actual temporal order. Finally, the *Discussion* section recounts cognitive operations in which the material activities are revisited, often as involving entities which are inferred from patterns in the data.

Second, research articles tend to exhibit a characteristic style. As is often noted, they use impersonal language, i.e., various devices such as passive voice, adjectival participles, nominalization, abstract rhetors and impersonal pronouns to conceal the agent in an event (e.g., Harré 1990; Myers 1990). Furthermore, events are often reported in the present tense. These strategies give the impression of a generic narrative, even though (unlike a narrative of nature) the statements in fact refer to particular events. Such narratives are thus pseudo-generic, but in this way represent events as exemplary.

Taken together, these organizational and stylistic features result in the fact that research articles do not resemble other text types that are more often addressed in terms of narrative. And yet they should indeed be seen as narratives.

Most definitions of narrative or criteria for narrativity of a text include the notion that narratives relate connected events. The verb ‘to relate’ can be read in a double sense here: narratives recount the events and they also establish relationships between them. There is some dispute about the nature of the connections among events that lend themselves to being narrated – for example, whether connections need to be temporal or causal (Morgan and Wise 2017). It is, however, almost universally agreed that a mere assortment of event descriptions or a mere chronological list of events does not constitute a narrative. Another central criterion is the involvement of human-like or intelligent agents in the events. Again, further aspects of agency might be required, such as the representation of the mental life of the agents or the purposefulness of actions (Ryan 2007).

Depending on whether the latter condition is taken to be necessary, or how one interprets ‘human-like’, one might doubt the status of narratives of nature discussed above. Research articles, however, are clearly narratives in the light of these core criteria. They report connected events, and they report them as connected. Indeed, many of the events are temporally ordered, with previous determining subsequent events. Furthermore, the events involve the researchers as agents, and their actions are purposeful and accompanied by cognitive operations.

Although it has been observed that research articles often do not provide a faithful representation of the research process which they appear to report, research articles are not typically perceived as works of fiction either (Schickore 2008).<sup>10</sup> Instead, they are generally presented and perceived as factual narratives (Fludernik 2020). Accordingly, an account of factual narrative is required.

One of the most robust theoretical tenets of narratology is the distinction between story and discourse.<sup>11</sup> Seymour Chatman, for instance, states that

each narrative has two parts: a story (*histoire*), the content or chain of events (actions, happenings), plus what may be called the existents (characters, items of setting); and a discourse (*discours*), that is, the expression, the means by which the content is communicated. In simple terms, the story is the *what* in a narrative that is depicted, discourse the *how*. (Chatman 1978: 19)

It cannot be assumed, however, that in the case of factual narratives the real-world chain of events constitutes the story. If the observation of common mismatch between research process and report is accurate, then for research articles, at least, it is clear that the chain of events reconstructed from the discourse, the story, is not necessarily equivalent to the chain of events that make up the research process. The story as the sequence of events reconstructed from the discourse by the reader is a mental representation, as cognitive narratologists maintain (Ryan 2007). I will thus assume a semiotic model of factual narrative according to which the discourse invokes a story in the mind of the reader, and the narrative (discourse + story) represents real-world events, whether or not the events of the story fully match the represented events.<sup>12</sup> I will speak of the represented events as being part of a 'practice-world', however, to avoid false contrasts, as discourses and minds are, of course, part of reality, and to point out that these narratives represent only a fragment of the world which is inhabited by the actual researchers.

### 12.2.2 *Communicating and Narrating*

By putting their names in the title section, researchers as authors of scientific articles clearly assume responsibility for what they write, and they will be held accountable by others. Yet even if the narrator is identified with the author of these and other factual narratives, it cannot be equated with the author.<sup>13</sup> Authors will carefully craft the narrator and adorn it with properties which

<sup>10</sup> Such observations are based on lab ethnographies or the analysis of lab notebooks (e.g., Holmes, Renn and Rheinberger 2003; Knorr-Cetina 1981).

<sup>11</sup> See Hajek (Chapter 2). <sup>12</sup> This model is thus Peircian, rather than Saussurean.

<sup>13</sup> Genette (1990) makes this equation.

they need not necessarily ascribe to themselves. In fact, as many articles – including Beadle and Ephrussi's – are co-authored, it would be challenging to construct a narrative voice that is faithful to the ways each of the authors perceives themselves or the group. In research articles, narrators are homodiegetic, i.e., they are also characters in the story (Genette 1980). Hence, by crafting the narrator, authors also craft the character of the researcher on the level of the story (for instance, as an able, attentive and accurate experimenter).

On the recipient side, the reader of a research article can be anyone, of course, even a philosopher of science looking at the text 80 years later to make it an example for narrative in science. There is also an implied reader, which can be inferred from paratextual as well as textual features (Iser 1978). Regarding the former, the journal in which an article is published is a key indicator. Textual features include the knowledge the authors take for granted – the kind of claims that do not need further justification or terminology, used without definition. The actual reader who matches the features of the implied reader is the addressee of the communicative act of the author.

Genette (1980) distinguishes the act of narrating from the discourse and the story. This act is performed by the narrator and is not part of the story; the addressee of this act can be called the 'narratee'. By creating the discourse, the author creates the voice of a narrator as if it (the narrator) had produced this discourse, and a narratee as the addressee implied in the discourse.<sup>14</sup> Thus the narratee cannot be equated with the reader addressed by the author. Furthermore, while the way the narratee is construed is informative of the way the implied reader is construed, these two categories need not necessarily overlap.

Based on the above model of factual narrative, I propose the following account of narrating. The narrator in the act of narrating represents the researchers in their role as authors in the precise sense that it is construed as having the same knowledge as the latter. The researcher-character, who is identified with the narrator, represents the researchers in their role as experimenters and reasoners in the practice-world. The narrator addresses the narratee to recount events in which it was involved as a character and which thus represent events in the practice-world of the researchers. A reader can cognitively and epistemically adopt the position of the narratee and thereby learn about these events. A reader who matches the implied reader will be more willing and able to do so. In this way, researchers as authors communicate information about the practice-world they inhabit as agents to a reader who might inhabit similar practice-worlds.

<sup>14</sup> For Genette (1990), narrating is prior to discourse and the author can perform the act of narrating directly in those cases where the author is equated with the narrator. See n. 22, below, for discussion of pronouns used in this chapter.

Narratologists routinely analyse differences regarding time (order, duration and frequency of events) between discourse and story.<sup>15</sup> Note, however, that if the story is distinguished from the practice-world events in factual narratives, the difference between these two regarding time is an entirely different issue. Take the order of events. The discourse might introduce events in the order B, A, C, while it can be inferred from the textual cues that the order in the story is A, B, C. The discourse then does not misrepresent the order – in fact, by means of the cues it does represent the events in the order A, B, C, and as the story is an effect of the discourse, the two levels cannot be compared independently. If the narrative (discourse + story) presents events in a given order A, B, C, while the practice-world order of events was in fact C, A, B, then this, instead, constitutes a mismatch (e.g., between research process and report). The above semiotic model maintains that the narrative still represents the practice-world events. By manipulating order, duration and frequency in the discourse, authors can create certain effects in the perception of the story. In the case of factual narrative, developing a story that misrepresents practice-world events in one aspect can help to highlight other important aspects of these events such that the overall representation might become even more adequate with respect to a given purpose.

The purpose of the research narrative, or so I argue, is to represent the practice-world events as an approach to a given problem. Seen from the perspective of the act of narrating, the discourse not only presents events which are reconstructed on the story level, but it consists of events of narrating. If the discourse introduces narrated events in the order B, A, C (including cues that indicate the order on the story level is A, B, C), then there will be three sequential events: narrating B, then A, and then C. The temporal order on the level of narrating might be employed to highlight an order of elements in the story world other than temporal (e.g., a conceptual order).<sup>16</sup>

On the level of narrating, the narrative might be described as a path through scenes in the story world which are considered in turn. By laying out a path, the narrator guides the narratee through the story-world. If this metaphor has a somewhat didactic ring, it is important to remember that it does not describe the relation of author and reader. The narratee in the research narrative is construed not so much as a learner who knows less about a subject but more as an apprentice who knows less about how to approach the subject. The narrator (who is also the researcher-character) will create a path connecting several diegetic scenes in which the character has certain beliefs, performs activities and observations, and reasons on their basis. The narratee *qua* guidee

<sup>15</sup> In a different way, Huss (Chapter 3) discusses the lining up of these different time patterns in terms of ‘narrative closure’.

<sup>16</sup> This possibility is of particular importance for narratives in science (Morgan 2017).

is thus introduced to the epistemic possibilities of the approach. A reader willing and able to adopt the position of the narratee can thereby learn about the approach.

### 12.3 Familiarizing a Community with an Approach through Research Narratives

#### 12.3.1 *The Case: A Research Article on Physiological Genetics from the 1930s*

I now turn to the work of George Beadle (1903–89) and Boris Ephrussi (1901–79) and in particular to one article, which can be analysed based on the considerations in 12.2. The article in question was published in the journal *Genetics* in 1936.<sup>17</sup> It was entitled ‘The Differentiation of Eye Pigments in *Drosophila* as Studied by Transplantation’ and reported research the authors had performed mainly in 1935, when Beadle, who was at Caltech at the time, visited Ephrussi in his lab at the Institut de Biologie Physico-Chimique, Paris.<sup>18</sup>

Leading up to Beadle’s Nobel Prize-winning work with Tatum, which is usually associated with a the ‘one gene – one enzyme hypothesis’ and thus considered an important step in the history of genetics, the article is relatively well known, at least to historians of genetics, as well as philosophers of biology. While firmly embedded in the genetic discourse and practice of its time, it presents enough novelty to display clearly the work it takes to familiarize peers with a novel approach and the novel epistemic objects emerging from it. Finally, in employing the IMRaD structure and an impersonal style, it conforms to salient conventions of much scientific writing in twentieth-century life sciences. It is thus well suited for such an analysis.

Many geneticists at the time aimed to understand the physiological role of genes, an enterprise that was often referred to as ‘physiological genetics’.<sup>19</sup> This was the kind of problem Beadle and Ephrussi set out to engage with. Their starting point was an observation made by Alfred Sturtevant. Sturtevant had studied genetic mosaics naturally occurring in *Drosophila* flies, that is, organisms which are composed of tissues with different genotypes.<sup>20</sup> In some flies it appeared that the eyes did not exhibit the eye colour that would be expected given their mutant genotypic constitution (indicated by other phenotypic

<sup>17</sup> The journal was founded in 1916. For the context of discipline formation, see Sapp (1987).

<sup>18</sup> On Beadle and Ephrussi’s work, see Burian, Gayon and Zallen (1991); Harwood (1993); Kay (1993); Kohler (1994); Sapp (1987).

<sup>19</sup> Also ‘developmental genetics’; see, for example, Harwood (1993). Beadle’s (1945) ‘biochemical genetics’ came into use only in the 1940s and had a more limited meaning, referring to the study of genes in biochemical pathways.

<sup>20</sup> In this case, this was due to the loss of an X-chromosome in some cells early on in development.

markers), but rather the colour-phenotype associated with the normal (wild type) genotype present in other parts of the body. From this Sturtevant concluded that a substance might circulate in the body of the fly, affecting the development of the eye, and that the gene, which was mutated in the eye, but was functioning in other parts of the body, was involved in the production of this substance (Sturtevant 1932).

Beadle and Ephrussi developed an experimental system based on implanting larval structures that would give rise to the adult eye (imaginal eye discs) into host larvae. The procedure resulted in adult host flies which harboured an additional eye in their abdominal cavity. This allowed them to create mosaics artificially and thus in larger numbers, and to produce adequate experimental controls. They clearly began with Sturtevant's hypothesis regarding the existence of a circulating, gene-related substance. Furthermore, hypotheses about the nature of gene action, in particular, the idea that genes affected biochemical reactions (either because they were enzymes or because they played a role in their production) were common (Ravin 1977). Nonetheless, Beadle and Ephrussi's article did not frame the work as testing any specific hypothesis about the relation of these entities, but rather as exploratory. Their project aimed at producing evidence for the existence and interactions of further elements in the biochemical system.

The epistemic objects they dealt with were thus on the one hand a well-established one, the gene, of which, however, little was yet known regarding its physiological function in somatic contexts, and on the other hand the assumed circulating substances, which were presumably involved in physiological reactions and in some way connected to the action of genes. The article reported the approach through which they achieved material and cognitive access to these epistemic objects and thereby established novel concepts referring to them. The approach enabled the formulation of hypotheses pertaining to these objects.

### *12.3.2 The Analysis: The Research Narrative as Path through Epistemic Scenes*

In the following, I will reconstruct the research article by Beadle and Ephrussi as a narrative. The narrative draws a path through several scenes in which the researcher-character performs material or cognitive activities in a story-world which in turn represents the practice-world of the researchers as experimenters. The researchers as authors construct the narrator to guide the narratee through these scenes in a way that enables an understanding of the epistemic possibilities of the approach they have developed and thus an understanding of the hypothesis put forward. I will identify four types of epistemic scenes (concerning what is known and what can be known through the approach), which roughly coincide with the canonical IMRaD sections.

I *The Positioning Scene: Interpreting a Problem Shared by a Disciplinary Community*

Both the journal in which Beadle and Ephrussi published their article (*Genetics*), as well as the things they take for granted, clearly indicate that their text implies geneticists as readers, as opposed to, say, embryologists.

The article does not begin with a hypothesis to be tested, but with a question or research problem to be explored, which pertains to the discipline of genetics, and more specifically to the subfield of physiological genetics.<sup>21</sup>

Prominent among the problems confronting present day geneticists are those concerning the nature of the action of specific genes – when, where and by what mechanisms are they active in developmental processes? (Beadle and Ephrussi 1936: 225)

With respect to this question, an assessment is made of the state of research at the time, which has a theoretical aspect (what is known or assumed about gene action) and a methodological aspect (how the problem has been approached). Regarding the former, it is asserted that ‘relatively little has been done toward answering [these questions]’ (Beadle and Ephrussi 1936: 225). Regarding the latter, advances that have been made are acknowledged:

Even so, promising beginnings are being made; from the gene end by the methods of genetics, and from the character end by bio-chemical methods. (Beadle and Ephrussi 1936: 225)

However, a methodological obstacle to theoretical progress is identified in the fact that those organisms, which are well-characterized genetically, are not studied from a developmental perspective, and vice versa. It is suggested that this impasse be confronted by studying developmental processes in a genetically well-characterized organism (*Drosophila*), and in particular regarding the formation of pigment in the eye, because many eye-colour mutants were known in this species (and because of Sturtevant’s previous findings).

As these considerations are written in an impersonal style, one could see them as considerations of the authors in the moment of writing. And yet they are narrated as considerations of the researchers at the time of setting up the project, as indicated by formulations such as this: ‘Several facts have led us to begin such a study’ (Beadle and Ephrussi 1936: 225). As such, they are events in the story-world (whatever was in fact considered in the practice-world). They constitute the beginning of the story, the initial epistemic scene in which the researcher-character (‘we’) – as a member of a discipline – finds

<sup>21</sup> On question-driven fields, see Love (2014); on exploratory research, see Burian (2007).

itself.<sup>22</sup> The narrator guides the narratee through the scene to let it understand how one can position oneself in the field characterized by certain problems and available methods, and to realize the advantages of the chosen approach.<sup>23</sup> This will resonate in particular with readers who are members of the community the authors belong to.

## II *The Methodology Scene: Having and Mastering an Approach*

The introduction of a new approach changes the situation in the field. It results in new possibilities for these researchers, and with them for everyone in their community. The new situation is characterized by the availability of the new experimental method, the new interpretation of the problem such that it can be addressed by the method, and the evidence and conclusions it affords. The narrator has already led the narratee to consider this new approach by setting it off against previous work in the *Introduction* section.

In the *Material and Methods* section, then, experimental events, consisting in applying a technique, are presented as generic, repeatable activities:

In brief, the desired organ or imaginal disc, removed from one larva, the donor, is drawn into a micro-pipette and injected into the body cavity of the host. As a rule, operations were made on larvae cultured at 25°C for three days after hatching from the eggs. (Beadle and Ephrussi 1936: 225–226)

In general, one function of this section can be to enable other researchers to reproduce the techniques in their own lab. In that sense, the text functions like a recipe (or ‘protocol’, in the language of experimental sciences). In this case, however, the detailed description of the technique has been relegated to an extra method article (Ephrussi and Beadle 1936). The information given in the *Material and Methods* section of the present article is possibly too sparse to allow for reproducing the experiments. This points to the fact that there must be another function: this section is similar to the exposition in a fictional text.<sup>24</sup> It introduces the reader to various elements (‘existents’) of the story, such as flies, fly larvae, donors, hosts, imaginal discs, various mutant lines and other things, and, furthermore, to the ‘habitual’ activities involving these elements performed by the researcher-character.

<sup>22</sup> The authors use an exclusive ‘we’ as narrative voice. The narrator/character acts as a single entity in the sense that the researchers are presented as interchangeable. To indicate this and to mark the narrator’s status as a textual entity that is different from the actual persons, I will refer to the narrator/character with the third-person singular ‘it’.

<sup>23</sup> On positioning, see Van Langenhove and Harré (1999). For another account that also puts ideas concerning positioning into relation with narrative see Berry (2021).

<sup>24</sup> ‘It is the function of the exposition to introduce the reader into an unfamiliar world, the fictive world of the story, by providing him with the general and specific antecedents indispensable to the understanding of what happens in it’ (Sternberg 1978: 1).

In the quotation, the first sentence uses the present tense. It is prescriptive in the sense of a protocol, but more importantly expresses the fact that the experiments can be performed by anyone who has the skills and access to the material. The second sentence is in the past tense, making it clear that the narrative nonetheless represents particular events when the researchers have performed these actions and indeed varied the conditions and found one that worked best. Following the contrastive presentation of the approach in the *Introduction*, the narrative in the *Material and Methods* section presents the character in a scene where it equips itself with a reliable method with which to approach the problem identified in the positioning scene.

### III *The Experimentation Scene: Addressing Questions Pertaining to the Problem through the Approach*

In the *Experimental Results* section, the narrative proceeds through questions which generate several epistemic scenes within the context of the broader disciplinary situation. These scenes are characterized by specific instances of ignorance (e.g., regarding the action of specific genes known through mutations) relative to the overarching research problem (gene action in general). These questions in turn have to be expressed in terms of the behaviours of the material in the context of the experimental interventions possible in the framework of the novel approach.

The path along which the narrator guides the narratee through these scenes is not fully determined by the temporal order in which the experiments were performed. Some questions can only be formulated if the data of previous experiments are obtained (or indeed only after conclusions are drawn from it, which are only presented in the *Discussion* section). But for many experiments the order in which they are performed is not relevant and hence also not represented in the text. The ordering created by the path is thus not always that of a sequence of events, but, instead, the intervention events are also ordered into series according to the logic of the experiments, in this case the combinatoric logic regarding donor and host genotype. The subsections have titles such as *Mutant eye discs in wild type hosts*, *Wild type discs in mutant hosts*, *Vermilion discs in mutant hosts*, etc.

For instance, the first subsection shows how the approach provides an assay to answer the question of which mutants are autonomous (i.e., when serving as donor, are not affected by the host tissue). The result that *v* and *cn* are the only exceptions, in that they are not autonomous, leads to a new epistemic scene. In the subsection *Vermilion discs in mutant hosts*, then, the narrative moves forward by means of a new question the researcher-character asks itself, and which can be addressed through the approach:

data should be considered which bear on the question of whether other eye color mutants have anything to do with this 'body-to-eye' phase of the *v* reaction [i.e., the influence of

the host]. This question can be answered by implanting *v* eye discs into hosts which differ from wild type by various eye color mutants. Such data are given in table 3.

[Table 3]

These data show that, when implanted in certain mutant hosts ([*list of mutants*]), a *v* optic disc gives rise to a wild type eye; in others ([*list of mutants*]), it gives an eye with *v* pigmentation. (Beadle and Ephrussi 1936: 231–232)

Most of the researcher-character's activities of intervention (implanting) and observation (dissecting and comparing eye colours) are compressed into one sentence and relegated to the table. Again, the formulation in the present tense and the impersonal style suggest that for any researcher, at any time, these interventions would result in these observations. And yet these sentences clearly refer to particular events in the story. The table, for instance, lists the number of individuals tested. We learn, for instance, that a *v* disk has been implanted in a *bo* host only a single time, while it has been implanted in 18 *ca* hosts. By having the researcher-character note the regularities and notable exceptions in the data, the narrator enables the narratee to grasp what can be done with the experimental method within the approach.

#### IV *The Interpretation Scene: Formulating Hypotheses in the Context of the Problem and Approach*

Already in the *Experimental Results* section, cognitive operations of the researcher-character are narrated:

From the data present above, it is seen that, in the cases of *cn* in wild type, *v* in wild type, and wild type in *ca*, the developing eye implant is influenced in its pigmentation by something that either comes or fails to come from some part or parts of the host. Just what this is, whether or not, for example, it is of the nature of a hormone, we cannot yet say. We shall therefore refer to it by the noncommittal term 'substance'. (Beadle and Ephrussi 1936: 232)

In this scene, the narratee is shown how the approach enables cognitive access to new epistemic objects through interpreting data resulting from past activities. It is in the context of the approach that the term 'substance' refers to new objects. It can then be used to formulate a new set of questions, which no longer concern the visible effects of the interventions in the materials, but the assumed entities which are not directly observable: '[I]s there only one substance? If not, are the different substances related and in what way? What is their relation to the genes concerned in their production?' (Beadle and Ephrussi 1936: 233).

These epistemic objects are thus introduced as objects of interaction, appearing when acting in the framework of the approach. For this purpose, in the

*Discussion* section, events reported in the *Experimental Results* section are revisited:

Since the pigmentation of a genetically  $v$  eye can be modified to  $v^+$  by transplanting it to a host which supplies it with what may be called the  $v^+$  substance, it follows that  $v$  differs from wild type by the absence of this substance. Evidently there is no change in the  $v$  eye itself which prevents its pigmentation from assuming wild type characteristics. It follows that the mutation  $v^+ \rightarrow v$  has resulted in a change such that  $v^+$  substance is no longer formed. (Beadle and Ephrussi 1936: 240)

The events of experimental intervention (implanting a  $v$  disk) are retold, but this time the unobservable events on the molecular level that are thought to link the intervention and observation made by the researcher are added. Yet the scene inhabited by the researcher-character is not one of experimentation but of reconsidering past experimental action. Together, the experimental scene, in which the narrator recounts what has been observed upon intervention, and the interpretation scene, which narrates the reconstruction by the character of what was actually happening on a hidden level, are akin to an 'epistemic plot'.<sup>25</sup> The narratee is led to understand the way activities in the context of the approach can be interpreted in terms of interactions with the epistemic objects.

#### 12.4 Conclusion: Exemplification of an Approach, between the Particular and the Generic

If the hypothesized entities and relations in the research article are compared with the narrative of nature in the review article quoted above, then it is clear that some – for instance, regarding the roles of the  $v$  and  $cn$  genes – achieved the status of accepted facts. Other propositions never went beyond the status of 'preliminary hypothesis'. Regarding the relation of substances, Beadle and Ephrussi provide the following hypothesis:

Such an hypothesis assumes that the  $ca^+$ ,  $v^+$ , and  $cn^+$  substances are successive products in a chain reaction. The relations of these substances can be indicated in a simple diagrammatic way as follows:

$\rightarrow ca^+$  substance  $\rightarrow v^+$  substance  $\rightarrow cn^+$  substance (Beadle and Ephrussi 1936: 243)

The entities and relations after the second arrow are conserved in the narrative of nature. For sure, Beadle and Ephrussi can claim to have discovered these substances and the relations holding among them and between the substances

<sup>25</sup> 'The trademark of the epistemic plot is the superposition of two stories: one constituted by the events that took place in the past, and the other by the investigation that leads to their discovery' (Ryan 2008: 7).

and genes.<sup>26</sup> But the details of the hypothesis do not matter much, nor which elements are conserved. When it turned out that the existence of an entity that would match their hypothesized  $ca^+$  substance could be established, this by no means diminished the value of the work. To criticize the hypothesis on its own terms required understanding the approach from which it emerged. Further results of that sort would come from the application of a more or less substantially modified version of the approach. Indeed, the research (Clancy 1942) which led to the abandonment of the  $ca^+$  substance, was ‘undertaken in order to repeat and supplement the experiments of Beadle and Ephrussi’ and ‘[t]ransplantation operations were performed by the method of Ephrussi and Beadle [1936]’. The author also added a novel technique for the ‘extraction and measurement of the eye-color pigments’ to the approach (Clancy 1942: 417, 419). Hence, amending Beadle and Ephrussi’s hypothesis depended on understanding, applying and modifying their approach.

The approach to the problem faced by the discipline, rather than the hypothesis, was thus the main achievement of Beadle and Ephrussi’s work. As stated right at the beginning of their article:

In this paper we shall present the detailed results of preliminary investigations [. . .] which we hope will serve to point out the lines along which further studies will be profitable. (Beadle and Ephrussi 1936: 225)

The actual process, the contingencies and detours are not the subject of the narrative. The activities are reported as they would have been performed if the researchers had known better from the beginning. This explains the common mismatch between research process and report. The result is an approach that works and that enables researchers to make certain kinds of claims. Understanding the approach is a condition for understanding the terms and the significance of the hypothesis, no matter how well supported it is by the evidence. Furthermore, it is this kind of knowledge researchers can employ to design new research projects (Meunier 2019). It is anticipated that further research ‘along these lines’ will lead to modifications of the theoretical claims. The purpose of the narrative is to make readers as members of the relevant community (geneticists) familiar with the approach, such that they understand ‘some of the possibilities in the application of the method of transplantation’ with regard to the shared problem of gene action (Beadle and Ephrussi 1936: 245). Accordingly, the hypotheses about these epistemic objects which might or might not enter the narrative of nature are not the only or even primary result.

<sup>26</sup> The actual distribution of credit is more complicated, because not only had Sturtevant anticipated the  $v^+$  substance, but Alfred Kühn and collaborators had delivered similar results working with a different organism (Rheinberger 2000).

In order to present the approach as universally applicable to the problem faced by the community, the narrative takes on the character of a generic narrative, even though it is in fact about particular events. It is thus pseudo-generic. More positively, the particular events are presented as exemplary; the research article constitutes an exemplifying narrative.

A significant stylistic difference between research narratives and many other accounts of personal experience is the use of an impersonal style and the present tense. These literary devices remove 'indexicality' (Harré 1990). In sentences of the type 'when implanted into a *x* host, a *y* disk gives rise to a *z* eye', the researcher-character is hidden by omitting the pronoun, while the present-tense detaches the activities from time and site. On the level of narrating, this has the effect that the narratee, guided through the experimental scene as an apprentice, can occupy the vacant position of the agent and perceive the event from the character's point of view (or rather point of action). A reader can then adopt the narratee's and thereby the character's position.

Grammatically, the character is only referentially absent but performatively present as the agent of implantation. Hiding the character thus renders the narrated events universal experiences of an unspecified agent. However, the occasional use of 'we', reference to individual instances (flies), and the use of the past tense anchor the narrative in particular events experienced by the character. Semiotically, the character as a complex sign denotes Beadle and Ephrussi. In so far as their experience is represented by the narrative, they are construed as exemplars of researchers in their community, who could all have similar experiences when performing the approach exemplified in the activities in which Beadle and Ephrussi engaged.<sup>27</sup>

Members of the community can read the text as narrating what Beadle and Ephrussi did or as stating what can be done regarding the problem. This ambiguity is indeed necessary. An approach is seen as universally applicable to a type of problem, just like a hypothesis is seen as universally answering to a problem. But, an approach, unlike a hypothesis, is not justified; it is not shown to be true, but it is shown to work. This is achieved by guiding the narratee along a path through various epistemic scenes, to see that one can do these things because they have been done.

In conclusion, while understanding the terms and the significance of a hypothesis (and not least the degree to which it is supported by the evidence) through understanding the approach is the condition for members of the community to accept the hypothesis as fact and incorporate it into emerging narratives of nature, the primary result communicated through the research

<sup>27</sup> Kuhn's (1977) notion of 'exemplar', as one reading of his term 'paradigm', refers to theoretical solutions to a problem. Here, instead, the focus is on practices including both experimental techniques and reasoning strategies, which exemplify an approach.

narrative is the approach itself, as exemplified in the particular activities reported. Rendering the events generic, by stylistic means, helps members of the community to familiarize themselves with the approach as generally applicable to a shared problem.<sup>28</sup>

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<sup>28</sup> The research was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – 362545428. I thank the editors, reviewers, and participants of the authors' workshop for helpful feedback. *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/](http://www.narrative-science.org/).

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