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INTRODUCTION

How scientific objects end

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In his paper "We Have Never Been Whiggish (about Phlogiston)" (2009), Hasok Chang pointed at the difficulty of writing a history of the so-called Chemical Revolution in terms of winners and losers, of new and old, of Oxygen and Phlogiston. Similarly, the recent collective volume *Ether and Modernity* (Navarro 2018) portrays a more complex image than that usually depicted of the presence of the ether in the early twentieth century. Both entities, phlogiston and the ether, have been popular examples in traditional, linear or progressivist accounts of scientific change. According to such accounts, new theories and experiments supposedly proved those entities never to have existed and they were only temporarily or even wrongly considered to be scientific. However, as many historians of science have shown, writing about the demise of scientific objects opens up a number of historiographical and ontological conundrums, encompassing topics like the identity of the no-longer existing objects, their previous and contemporary scientific value, or the processes of scientific change.

Following this thread, the papers in this special issue address the question of the death of scientific objects head on. In doing so, the issue employs the term "scientific object" quite loosely, so as to include theoretical entities, representations, practices, natural substances and artificial products, laboratory instruments, scientific theories, etc. The death, demise or termination, addressed here refers to the histories of how scientific objects end, either by disappearing from the scientific stage or by their transformation in such a substantial way so as to give birth to a new object.

Generally speaking, the demise of scientific objects has often been an indirect subject for the history and philosophy of science. From the once triumphant notion of discovery to the more chronologically expanded idea of emergence; from the analytical idea of proof to the at times misused label of social construction, the appearance of new objects on the scientific stage somehow involves the abandonment of previous ones. But while scientists, historians and philosophers have been traditionally more interested in origins and development, in birth rather than in death, a number of historians of science have, in the last few decades, directly addressed the complexities of the end of some scientific objects or practices.

The now classic *How Experiments End* by Peter Galison is perhaps the best-known example of the latter, with his slow-motion and multi-faceted analysis of the way experimenters reach empirical decisions in contemporary physics. His main point was that "there is no strictly logical termination point inherent in the experimental process. Nor, given the heterogeneous contexts of experimentation, does it seem productive to search after a universal formula for discovery, or an after-the-fact reconstruction based on inductive logic" (Galison 1987, 3). There are many summaries and analyses of the book in the literature and this is not the place to repeat them. However, there is an aspect in Galison's examination of the "termination" or "end" of experiments worth mentioning here: his analysis is dynamic insofar as the whole process of reaching a final decision is far from a mere empiricist appeal to "the facts," but is instead a journey full of pre-suppositions, negotiations, agreements and final decisions. And yet, the final point of an experiment remains

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fixed, given, static; the process by which an experiment ends, however convoluted and multi-faceted, would always produce specific experimental data, not evolving or changing results. In other words, experiments of the kind analyzed by Galison finish with an end result.

More recently, the collective volume *How Collections End*, reminiscent of Galison's title thirty years earlier, has explored the demise of scientific collections and objects in museums and similar institutions. The "end" here refers to physical objects, considered either individually or as compilations, and their changing meanings—from scientific objects in use, to items about science in the past worth preserving, to potentially destroyed or redundant objects. As the editors argue, the preservation of objects and collections depends on their very physicality (some items are too fragile to preserve), on legal grounds (ownership may often be challenged), on changes in moral or political ideologies, or on sheer economic priorities: "collections can endure only when they are supported by relevant expertise, communal desire and social order" (Jardine, Kowal and Bangham 2019, 3). Because of all this, "the term 'ending' is broad and productively ambiguous, and can refer to changes to a collection's identity, perceived value, geographic location and meaning. To pay attention to ending is to pay attention to the shifting fortunes of things, to the labour of their maintenance, and to the reality of dispersal as a negative and positive force" (ibid., 4).

The point I would like to borrow from this volume is that, contrary to the static outcome of the experimental ending à la Galison, scientific "collections can die before their time, but they can also outlive their usefulness (only to become useful again under a new paradigm). In other words, collections are at times out of step with other aspects of scientific practice" (ibid., 4-5). This ontological insight is relevant for the papers that follow in this special issue: scientific objects, understood in the broadest possible sense, may have a dynamic ontology, able to adapt to their wider scientific and cultural contexts. The old Popperian dream of straightforward falsification and definitive abandonment of scientific objects does not seem to hold, and their identity can be malleable to the point of acquiring different uses and different ontologies *qua* scientific objects. From this point of view, termination would neither be a straightforward event nor one that necessarily brings the object to a final end.

Moreover, the historian of science may have an active role in the definition and re-definition of the ontology of dead scientific objects. Post-hoc histories and the narratives of their abandonment are not neutral about their ontology and can often create a new entity, one that might indeed be dead, but not necessarily equal to the one that was supposedly abandoned or even killed. In other words, writing about the demise of scientific objects can turn into a process of object formation that perfectly demarcates the properties of the dead objects in new ways, and thus regards as non-existent an object that, as clearly defined *a posteriori*, can hardly be said to have ever existed. I shall come back to the question of identity further down.

Talking about scientific objects using terms such as "death" and "identity" introduces the possibility of utilizing *biography* as a historiographical category. It has indeed been fashionable in the last decades to write about biographies of all sorts of things. In most cases, *biography* seems only to be a metaphor or, even worse, a catchword and commercially successful substitute for *history*.[1] However, a number of historians and philosophers of science have seriously explored the possibilities— both theoretical and material— of biographical approaches to scientific objects. Among the best-known attempts to so do are Theodore Arabatzis' (2006) biography of the electron and Lorraine Daston's (2000) edited volume *Biographies of Scientific Objects*. While one can legitimately criticize any use of biography to write the history of non-humans, let alone inert or immaterial entities, these works show the validity of the approach, not as cheap anthropomorphism, but as a way to account for the stubbornness or, as Arabatzis calls it, the recalcitrance of scientific objects:

[1]For a thorough critique to the use of "biography" of scientific objects see Söderqvist (2020).

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> This approach amounts to considering theoretical entities as active agents whose internal dynamic transcends the beliefs, abilities, and wishes of human actors and acts as a constraint on the development of scientific knowledge. Even though they are the products of scientific construction, they have a certain independence from the intentions of their makers; that is, they have a life of their own. (Arabatzis 2006, 36)

In other words, while scientific objects are a product of the (individual or collective) scientific mind's attempt to make sense of the world, once their formulation has started, they acquire a robustness, an identity, a life of their own, which restricts the modifications to which they can be subjected. As a matter of fact, part of Arabatzis' motivation to talk about the biographies of theoretical entities was his aim to offer a historical and philosophical approach that was neutral in regards to the heated question of realism in theoretical physics. Thus, scientific objects à la Arabatzis did not need to really exist in order to have a life and "legitimately become the subject of biographies" (41). But realism was not excluded: one might write a biography of the representation of an entity without necessarily identifying the representation with the entity itself.

How to write such a biography? Arabatzis gives us a short recipe:

> One could use expressions like "birth," "character formation," and "death" to trace the career of theoretical entities. The birth of a theoretical entity amounts to the emergence of an explanatory representation of some unobservable entity, in response to various problem situations, empirical and/or conceptual. . . . After the birth of a theoretical entity, its character, that is, the properties attributed to the corresponding unobservable entity, the laws that it is supposed to obey as well as the experimental constraints governing the representation of its behavior, is gradually formed. (43-4)

But what about the end of most biographies, namely death? Arabatzis does not address this subject. In *Representing Electrons*, he writes only that "*Death* usually comes when the theoretical entity ceases to aid theoretical practice and runs out of explanatory power," and that "typically, the death of a theoretical entity is accompanied by the birth of another entity, which takes over part of the explanatory role of its predecessor" (44). However, the demise of a scientific object cannot be that simple. The Kuhnian undertone of death by substitution shies away from the complexities of writing a biography of something that is, in time, perceived to be wrong, false or, at most, simply partially valid. Indeed, Arabatzis' example, the electron, is still in good health. But what about entities no longer regarded as scientific, or whose scientificity has evolved to incorporate new objects, new uses or new identities (singular or plural)? For Arabatzis, the biographical approach only makes sense if there is one entity, one representation in the electron's case, with a core set of properties, that somehow constrict its sameness (49). But the question of identity may be easily challenged, as some of the papers in this issue show, when we pay close attention to the transformation that the demise of scientific objects brings with it. Moreover, and as I have already suggested, looking closely at the demise of scientific objects may shed some light about the ways in which the identities of scientific objects may change before and after their expiration.

Daston's (2000) *Biographies of Scientific Objects* is often quoted as another attempt to explore the use of *biography* as a historiographical category for analysis. Interestingly, however, her introduction to the volume does not directly mention *biographies,* nor do any of the chapters make any explicit use of the word, except for one (Rheinberger 2000). And yet, the word seems to permeate what she calls "applied metaphysics," by which she means an approach that is "orthogonal" to the debates between realism and constructivism in the sciences, since "it posits that scientific objects can be simultaneously real and historical" (Daston 2000, 3).

The examples in that volume stem from the pure and applied, the experimental and the theoretical, the natural and the social sciences. They deal with "how a heretofore unknown, ignored, or dispersed set of phenomena is transformed into a scientific object that can be observed and

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manipulated, that is capable of theoretical ramifications and empirical surprises, and that coheres, at least for a time, as an ontological entity" (ibid., 5). All this is, of course, reminiscent of Ludwik Fleck's *Genesis and Development of a Scientific Fact,* where the process of formation of facts, objects or practices can be explained as the outcome of a complex process of multiple epistemic forces interacting with each other. However, and although Daston acknowledges that when "new scientific objects pour forth, old ones fade away," (5) most of the examples in that volume have again to do with novelty and not with demise, as if biographies were more about birth than about death.

In this special issue of *Science in Context*, Arabatzis' contribution argues for the validity of biographical approaches to scientific objects, even if only in a metaphorical sense. This time, however, he explicitly addresses the problem of death or, as he prefers to call it, of the fading away. To do so, he first draws a taxonomy of scientific objects, dividing them into four categories: natural vs artificial objects; natural regularities vs laboratory induced phenomena; manifest vs hypothetical or hidden entities; experimentally unobservable vs routinely manageable objects. In all cases, death cannot be described as an event but, rather, as a process, and one that may even traverse different disciplinary or cultural geographies. In an extreme case, a scientific object may be both dead and alive, at least for some time, in different contexts.

Arabatzis finishes his article with a brief historical analysis of the demise of the ether, which he uses as an illustration of the biographical approach's utility and applicability. Navarro's paper also addresses the end of the ether, but from a historiographical point of view. Rather than giving an account of the theoretical and experimental steps that led to its disappearance, the paper explores how the accounts of the death of the ether played an active role in its demise both during and after its abandonment. Using the analogy of obituaries, it argues that the histories about the end the ether seem to have helped in both rejecting it and in defining a clearer identity of the non-existing object. In other words, the paper discusses how the narratives of death may end up creating an object for present-day historians that is sensibly different from the object past scientists had in mind.

Following his ideas on scientific pluralism and on the relevance of the history of science for the practice of contemporary physics, Hasok Chang's contribution to this special issue deals with the multiple lives of the contact potential, a concept first used by Volta in the late eighteenth century. While officially dead, the contact potential seems to surface and re-surface in several moments in history to explain diverse phenomena related to electricity. These are not, in Chang's interpretations, resurrections of the concept, but simply the manifestation that the contact potential is "undead". All the different phenomena that could be explained by using the contact potential throughout the last two centuries, he argues, never had an alternative unified explanation. Thus, while partial, undefined and deficient, the contact potential was (and still is) handy and fruitful in the specific areas of scientific practice.

Two papers in this issue focus on specific, material objects. In the first, Daniel Belteki explores the changing roles of the astronomical tool known as the Airy Transit Circle in Greenwich, which began its life as the center of the determination of the meridian in the Royal Observatory and has now disappeared almost entirely from the public imagination. Central to Belteki's argument is the process of the instrument's transformation from a practical astronomical tool to a frozen museum piece. This process took the form not of a simple transportation of the instrument from the laboratory to the museum (since in this case they are both the same place), but of the gradual transformation of the object, *qua* living instrument, until it was declared obsolete. Because the instrument in Greenwich known as the Transit Circle was, in fact, continually modified, changed, improved, dis-assembled and re-assembled on numerous occasions, so as to keep it useful, one may wonder what kind of continuous existence, if any, did the Airy Transit Circle have.

Even more complex seems to be the problem with the objects addressed in the second of these two papers: human remains that have become objects to be stored, studied and displayed in museums—the relics of the once-popular phenomenon of the anthropological collection. Looking at

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the fate of one particular specimen in Francis I. Rainer's anatomical collection in Bucharest, Alexandra Ion explores the epistemological, historical, but also moral problem of dealing with human remains. In her nuanced reading, Ion argues that dead bodies or body-parts were the soul of an anatomical and anthropological collection. Their very nature was to be part of a research and educational project that included practices of preservation, research philosophies and cultural dissemination. In exploring the ways museums deal with such specimens, Ion mentions nostalgia as an attitude often found among curators (nostalgia for unfinished lives, for scientific or cultural projects); she also suggests seeing them as "modern ruins" rather than dead objects.

Corinna Guerra introduces us to another way death permeates scientific objects, by taking us to the Kingdom of Napoli and paying attention to the status of the ashes from the eruptions of the Vesuvius in the late eighteenth century. What had historically been regarded as a nuisance – simply *dust* – or a sign of how an eruption might progress as compared to previous events, turned into the scientific object *volcanic ashes*, to which the new chemical ideas and technologies of the time could be applied. Being a random phenomenon of Nature, eruptions turned the slopes of the volcano into improvised and ephemeral scientific laboratories where naturalists, chemists and public authorities had to negotiate the nature of lava and ashes and their potential dangers to the population. Both ashes and lava had a short life-span due to their transformation as they cooled down; and, following the metaphor of life and death, their symbolism was also unstable, as those who studied them either argued that they were a source of danger and poison for the nearby inhabitants, or touted their enormous life-giving potential as fertilizers.

Finally, Mat Paskins thinks of the disappearance of scientific objects from another perspective. The object he discusses, chemical dyestuffs, has not disappeared. We find these dyestuffs everywhere, in many industries. Yet, in Paskins reading, they have turned into habitual, everyday products in industrial processes, but have ceased to be an area of scientific research. No fundamental changes have happened for decades in the dyeing processes, and dyestuffs have long ceased to be the promising avenues of research they once were. This would, thus, be another way for scientific objects to die: not by disappearing but by ceasing to be "scientific", by becoming normalized and naturalized.

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