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COMMENTARY

Why Collect Science?

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In this critical assessment of the 'museology of science' I cherry-pick recent scholarship and practice to unpack the functions of science collections. Some practices (exhibition, engagement, study) have already attracted considerable attention, others not yet (storage); but all tend to be considered separately as case studies from particular institutions and for particular disciplinary audiences. Juxtaposing different reasons to collect reveals both the tensions inherent in science collections and the opportunities these collections afford, especially around their materiality. This is why we have collected science, and why we should continue.

Keywords: exhibitions; materiality; research; science engagement; science and technology museums; storage

Introduction

'You owe me a new mobile', grumbled to me a colleague from another department soon after I began working in the National Museums Scotland's Science and Technology curatorial team. His daughter had seen her phone model – a recent one – of a well-known mobile brand in the new communications gallery of the museum, and had concluded that it was therefore historical, and should be replaced. Never mind that the exhibit was showing contemporary technology – in her mind the museum was indelibly associated with bygones.

This is one of the many contradictions inherent in science and technology collections: they are flexible enough to hold the antique and the cutting-edge; they show great discoveries and unfinished research; they appeal to schoolchildren and Nobel Prize-winners; they accommodate the breathtakingly massive and the incredibly minute; they are geared towards the physical but seek to represent the intangible; they show geographically specific evidence of a de-localized enterprise; and they are associated with object-free interactivity while storing hundreds of thousands of resolutely material things.

Other kinds of museum collections experience these tensions to varying degrees. My intention here is to reflect upon how these incongruities shape the understanding of science collections and how the material culture therein can best be exploited, and to unpack some of the assumptions that curators and stakeholders make about these objects. The tasks of collecting and exhibiting science objects are difficult, expensive and often thankless. Given there are many other ways of recording and experiencing science – digitally and televisually, as well as physically – why do we continue assembling physical collections? What should the function of the science collection be in the twenty-first century?

These are big questions – in such a short opinion(-ated) piece, therefore, some parameters are necessary: this is not a comprehensive survey of the growing literature on science museums, but rather a brazenly partial review of some interesting writing and practice. I will take for granted well-known foundational work (e.g. Butler 1992; Macdonald 2002) and instead cherry-pick from the mushrooming scholarship in the last decade. Too much of this is spread out over different fields; I seek here to present these diverse literatures in dialogue. Illustrative examples of practice are drawn largely from the UK, especially (and unashamedly) taken from my own institution, National Museums Scotland. This multi-disciplinary collection of art, natural history, ethnography and social history has a science and technology element that includes scientific instruments, photography, communications, medicine, engineering and transport. In 2016 we redisplayed the collections in our flagship site, the National Museum of Scotland (**Figure 1**), and we now use these galleries as a platform for new collecting, research and engagement (National Museums Scotland 2016).

In spite of the range of our own collections and my own previous forays into the natural sciences and anatomy (e.g. Alberti 2008; Hallam and Alberti 2013), I focus here on science, technology and medicine (committing the cardinal sin of using 'science' as shorthand for all three when it suits). I want to respond to the challenge laid down by two colleagues, who tasked those who preserve scientific heritage to remember why they do it (Lourenço and Wilson 2013). Accordingly, my discussion will begin with collecting, then move on to the reasons for doing so: first,

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Figure 1: The science and technology galleries in the National Museum of Scotland, redisplayed in 2016. Image © National Museums Scotland.

storage (an odd choice that I will explain), then research, exhibitions and engagement.

With museum professionals and scholars working within and on science museums in mind, I seek a middle ground between on the one hand the considered rigour and admirable pragmatism of descriptive function surveys (Achiam and Sølberg 2016) and on the other hand the out-and-out provocative prescription of Ken Arnold and Thomas Söderqvist's *Dogme*-style manifesto (Arnold and Söderqvist 2011). Rather, I review and reflect on the potential of science collections: a potential, I will argue, that involves embracing the materiality of science.

To Collect

To grasp the current constitution and potential of science collections we need to understand how they came to be. Many have their roots in nineteenth-century expositions such as the 1876 Loan Collection of Scientific Apparatus in London (Bud 2014). Early museum intentions included showcasing the latest and best in the useful arts, which was the aim of the chemist George Wilson when he established the Industrial Museum of Scotland, an ancestor of the present National Museums Scotland collection (Swinney 2013). There and elsewhere such contemporary material culture was accompanied by collecting to celebrate the heritage of science. In Oxford and Cambridge, for example, private collections seeded university history of science museums, shoring up the professional identity of disciplines and alumni, and spawning teaching programmes (Bennett 1997).

In the later twentieth century, collectors and curators fuelled a micro-industry in historical instruments as history of science developed as a standalone academic discipline. Meanwhile, museums continued to display recent science, often hand-in-glove with corporate and government bodies. A telling juxtaposition of the historical, contemporary, and predictive in Edinburgh were three late 1960s exhibitions in rapid succession, prompted by and prompting new acquisitions: telescopes of the eighteenth-century optician James Short; a lunar display featuring a newly collected packet of the dried soup prepared for the Apollo 11 mission; and a display of the future of electrical engineering, featuring the products of the flourishing 'Silicon Glen'.

This past/present/future triple collecting endeavour continues to this day. And yet to acquire historical instruments requires very different skills and networks to collecting contemporary material. Purchasing an astrolabe at auction, for example, demands connoisseurship and deep pockets – few institutions can sustain this in a meaningful way, and it may be wise for them to leave others to it. One can instead (or as well) focus on material that is old enough to be obsolete but not so old as to be collectable – such 'rescue collecting' requires a fleetness of foot and good connections in scientific and technical sites. My National Museums Scotland colleagues are expert at visiting power stations to acquire material for the energy collection when an occasion arises at the eleventh hour before decommissioning (Cox 2016; Robertson 2017). With a little more breathing space (in this instance), earlier this year colleagues visited the recently closed Longannet Power Station, the last in Scotland to be fired by coal. Within this dormant giant they selected two telephones that connected the station to the National Grid; hazard-free and small enough to be manageable, but bearing potential to tell rich stories about energy and networks.

Contemporary artefacts have other challenges than size, of course, such as intellectual property rights, and the 'black-box' problem of incomprehensibility (Pantalony 2015); but they also present opportunities. Museums can build sustainable partnerships with research and innovation organisations; in the medium-term at least, universities in the UK may be motivated by the Research Excellence Framework impact objectives. If curators consider carefully and navigate the motivations of their partners, then 'co-collecting' endeavours can give rise to a sustained and manageable source of material (Boyle 2016; Graham 2016). A friend indeed is the laboratory colleague who is amenable to 'post-it note' collecting: identifying key objects during their working life to be sent to the collection as soon as they are replaced, complete with accompanying stories. This is not new: we have instruments in our collection that bear the plaque added by the Photogrammetric Society in the 1980s requesting that the society be informed before sale or relocation (see Burnside 1993).

Whether collecting historical or (especially) recent science, the sheer volume of material can be daunting. Never mind *why* collect science, the question of *how* is challenging enough. As in other areas, institutions collect on a project-led basis, often (but not always) for display purposes; the new galleries at National Museums Scotland

prompted collecting activity around mobile telephony (hence my opening anecdote), and the Science Museum Group are collecting intensely for their forthcoming medical galleries (a £24 M project due to open in 2019). We should however be alert to opportunities for ongoing collection development where resources allow, and for non-exhibition projects too. Collecting cannot be comprehensive, in this area as in most others, but collections can remain dynamic with careful focus and inter-institutional cooperation (or at least communication). After all, there is more than enough scientific, technical and medical material culture to go round. But where, then, to put it?

To Store

Almost all of the things we collect will spend almost all of their museum afterlives in store; while to store may not be an explicit reason to collect *per se*, given the reality of the situation we should embrace storage as a practice and as a subject of study. In curatorial liaison with donors and collecting partners – who are often surprised by the situation – we should not only manage expectations in this respect but also celebrate science storage.

Objects may spend a few months in a temporary exhibition, or a few decades on permanent display; but museum stores hold them – in principle – *forever*. Different heritage professionals have different concepts of posterity (Lindsay 2005), but there is no doubt that we are dealing with longer periods than the next business quinquennium. Most of the scientific objects in our stores have been or will be there for far longer than their working lives were. This has practical and financial consequences: at National Museums Scotland we recently calculated our real costs of acquiring, assessing, documenting, and storing an object. Accepting that including an infinite time period would confuse our calculations, we broke storage costs down into decades to generate a unit cost. As one colleague philosophically reflected during this otherwise actuarial exercise, we are dealing with '*fragments of eternity*'.

But are they worth it? Should we re-interrogate our custody of thousands of objects – hundreds of thousands – not all of them catalogued, and a significant proportion of which will very probably never be used? *Yes*, if we accept that the value of objects lies in their *potential* for other functions mentioned below (although we should be sceptical of the collecting justification that 'it *might* be useful, one day'). *Yes*, if we accept that the store may well be their ultimate resting place, and that the museum store as a space, as a facility, has merit in and of itself over and above being a holding bay for other spaces and functions. Many museum stores are active places where many museum professionals spend a considerable portion of their working lives, and where cataloguing, photography, and other activities take place. Readers of this journal will not subscribe to the common misconception that industrial technology and the like is so robust that it needs little collections care; science stores, like others, are sites for painstaking and expert cataloguing, conservation, preservation and curatorial research.

Besides which, conservators and curators already know what recent scholarship has shone a critical light on: that science stores in particular are magical places; the work that goes on in them evidences object-love (Geoghegan and Hess 2015); and they are worthy of museological and historical analysis (Brusius and Singh 2017; Liffen 2010). Stores provide a very different experience of the objects, a visual grammar very different to displays. In science stores, scale is an especially important factor. We should not be blasé about the sheer wonder stimulated by the vast objects therein. In the largest science and technology store in our National Museums Collection Centre, lighthouses rub shoulders with steam excavators and cryogenic bubble chambers (**Figure 2**). The sheer quantity of material – row after row of computers, or examples of dozens of oscilloscopes (**Figure 3**) – has an impact upon the quality of the experience: it allows for visual and intellectual comparison, albeit cut loose from the comfort (or tyranny) of the interpretive label. People who visit our stores enjoy them enormously.

Figure 2: Size matters. A science and technology store in the National Museums Collection Centre. Image © National Museums Scotland.

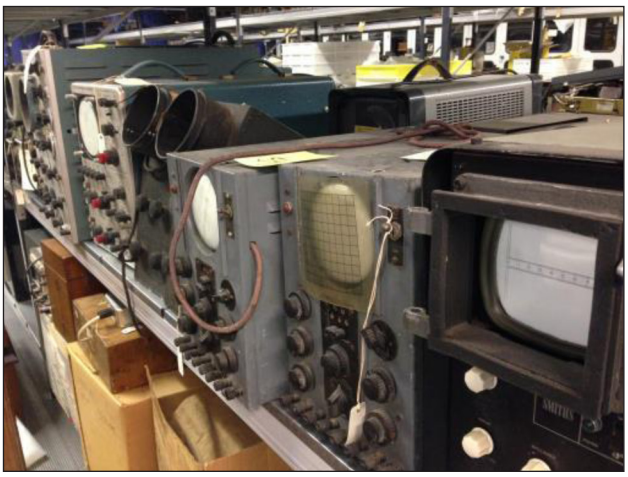

Figure 3: Quantity and quality. Oscilloscopes in the National Museums Collection Centre. Image © National Museums Scotland.

Which is not to ignore the considerable security and logistical challenges of providing access, compounded by collection managers' house pride – few unlock the doors of their store to their fellow professionals without abject apologies for one perceived sin of untidiness or another. A vogue in the last two decades for overcoming these challenges has been the effort to provide 'visible storage', through which the un-invigilated might pass without draining precious staff time; such facilities are entirely commendable, but rarely are they genuine storage areas – rather, they become extensions of display space (Reeves 2017). Besides which, such a store is *visible*, but denies other sensory experience: where is the *audible* store, or the *haptic* store? Science and technology objects cry out to be handled as they once were; managed carefully, multi-sensory access can be provided.

We should render our stores as accessible as resources and safety allow, accepting that they will never be a destination for mass visits, but rather that they can provide qualitative experiences for particular user groups. The enthusiast communities that coalesce around particular objects or categories benefit greatly from the more focussed engagement a store tour provides, and in turn provide valuable expertise for the holding institution. These quiet sites stimulate important *dialogue*.

In short: stores should be championed better as active, dynamic, wonder-full places rather than dormant warehouses. The epithet 'store' does them no favours, of course: at National Museums Scotland we like 'Collections Centre'; Glasgow Museums has its 'Resource Centre' (with its 'pods'); and at the new facility at Kelvin Hall (a giant former exposition building), users can research collections from the University of Glasgow, view films from the National Library of Scotland, and then go to a fitness class. These are lively, functional spaces, and we should be proud to be collecting objects to bring there. As an object donor, wouldn't you be happier to transfer your precious instrument to spend eternity (or fragments thereof) in a study centre than in a warehouse?

To Study

Even better, however, would be to give an object to a *research* facility. What keeps the collection from falling into forgotten repose is the potential to be awoken by the curious gaze and caress of the scholar. We collect the material culture of science, as we do art and nature, so that we may learn from it, so that it may be *researched*.

The scientific instrument has particular characteristics and contradictions as a research resource. Alongside the manuscript and the book it is an important historical text; but it has materiality that can reveal what other media cannot. It can prompt different questions, especially around practice. It is evidence of the exploration and understanding of nature, but it is not natural phenomenon itself, unlike the specimens in a *natural* science collection – brass and glass rather than fur and feathers.

Traditionally the science collection has been a research resource for curators and other historians of science, to generate published research outputs. In the UK, the development of history of science as a discipline and the construction of a professional community of specialized science curators were contemporaneous in the post-war decades. The two were related, but not always as closely as we might assume. From then until now there has been a tension between curators buffeted by the changing political fortunes of museums and university-based academics experiencing a series of 'turns' – pragmatic, spatial, and literary. But it is unclear what the impact of the supposed 'material turn' has been. There is a well-established but small cadre of instrument scholars, mostly but not exclusively in museums. They include the Scientific Instruments Commission, the 'Artefacts' conferences and the French national network devoted to recent scientific heritage (for recent outputs of these three groups, see Morrison-Low, Schechner and Brenni 2016; Boyle and Hagmann 2017; and Ballé et al. 2016, respectively). But despite eloquent calls for other historians of science to make better use of material culture (Cavalli-Björkman and Lindqvist 2008; Taub 2011), it is unclear whether the sector as a whole has materially turned.

There are of course examples of successful collaborative research projects between universities and museums in the UK – the recent 'Board of Longitude' project, for instance, between the University of Cambridge and Royal Museums Greenwich (Higgitt and Dunn 2014; Schaffer 2014), and the 'Metropolitan Science' project now underway between the University of Kent and the Science Museum. Both projects involve prolonged consideration of instruments alongside texts and images to understand the culture of science in the long eighteenth century; collaboration between scholars employed by museums and those in universities; and careful reflection on material culture as source material. They also involve sizeable exhibitions and engagement (functions discussed below). Beyond these projects, and with similar blended intentions, research internships (such as those at Royal Museums Greenwich) are laudable, and collaborative doctoral funding has brought a new generation of researchers into collections (AHRC 2017).

The publications resulting from such projects include important and innovative work, and consequently we know more about collections, and about science and technology; certainly these projects involve cutting-edge research *about* instruments. But how much of this work is undertaken *with* instruments (Anderson et al. 2013)? Historians – myself included – can write about material culture remotely from the museum object (Alberti 2005). As it was a decade ago, the relationship between history of science research and material culture remains chequered (Bennett 2008; Lourenço and Gessner 2014). Beyond the scientific instrument community, how much do historians of science use things?

In Edinburgh, we have custody of one of the finest science collections in the UK, well catalogued and with a reasonably high international profile. Across the department we responded to around 300 enquiries in the last year; fewer than one quarter were from researchers in universities or others undertaking academic enquiry. Only

a handful of researchers then came to spend time with the collection; and our attempts to capture outputs yield very few publications drawing on our collections. Other science collections may attract more use (although never to the level of bench time at large natural science collections), and examples of excellent research can always be provided. But we would do well to assess the profile of museum object analyses in the sector, as Joseph Corn did twenty years ago (Corn 1996). We may need to face the brutal truth that only some historians of science will focus on our holdings (and, even then, only on a fraction), and most will not do so at all.

This is not a criticism of the history of science community; they (like the rest of us) experience considerable time-pressure; and many of our colleagues ask research questions that cannot be answered with objects. The material turn may yet, well, materialize. But in the meantime, others *are* interested: we need to cast our disciplinary net more widely (Craciun and Schaffer 2016). Anthropologists have been sniffing around science museums for decades (Macdonald and Silverstone 1992); artists roam widely in pursuit of research material (Carnall 2013); and more recently, geographers have been exploring them (MacDonald and Withers 2015; Naylor and Hill 2011). We need to work harder to promote the multi-disciplinary potential of science collections, and to capture the results. Furthermore, as well as spanning disciplines, science collections span media; it could and should therefore be easier to facilitate the inter-medial study of objects, images and texts.

Besides, publications are not the only products of museum research; we need not be bound by definitions designed for university metrics (Treimo 2017). We know that museum research is qualitatively distinct, and there are eloquent analyses of its relationship with science exhibitions (Macdonald and Basu 2007). The importance of exhibitions will be revisited in the next section, but here it is important to note that there are yet still other outputs of museum research. Like other collections, we need to think more widely about what research is.

Too often in discussing collections-based research we forget to include and/or connect to audience research; visitor evaluations are outputs. Thinking about audiences, those other 75% of enquiries mentioned above included a number under the clumsy category of the 'general public', wanting to know technical details about artefacts and machines – the responses include material and record consultation; they are outputs. Blogs and other digital products are outputs. We should not overlook collections management activities, especially documentation – catalogue entries are outputs. Acquisitions take careful review and study; they are outputs. Deaccessions perhaps even more so involve thorough explorations of the provenance and function of objects (so that we often know more about the objects we transfer than about many of those we retain); they too are outputs.

Objects can enable work that blends research, collection development and engagement in a virtuous cycle. Research into science collections is a broad endeavour; it is often a gratifyingly collaborative endeavour, and increasingly an interdisciplinary one. (And, since we live in the real world: as the Longitude and Metropolitan Science projects show us, it can be a *funded* endeavour).

To Exhibit

My unit of analysis in this piece is the science *collection* rather than the science museum, because I wanted to consider the bulk of the iceberg under the surface. But of course the bulk of the literature on science museums (whether anthropological, museological or historical) focusses on this most visible reason to collect science – exhibition. The published corpus on this topic is bountiful and growing: one recent anthology included no fewer than 36 case studies of exhibitions across two volumes (Filippoupoliti 2010), and reflective analyses of exhibitions can be found in the *Science Museum Group Journal* (e.g. Blatchford and Sidlina 2015). There is little need to add to this pile here, but I do want to draw out two related and interesting aspects of science exhibitions: their non-scientific appeal; and the role of controversy.

There is a tension and an opportunity inherent in our ageing collections. In many cases we are expected to illustrate universal ahistorical scientific principles using artefacts that are geographically, socially and historically specific. Some of the most appealing exhibitions, however, embrace the cultural qualities of science objects: especially, their *beauty*. On purpose or not, an instrument can have aesthetic appeal, and this has been exploited for some time (Museum of Modern Art 1934). My favourite moment in the opening night of the new galleries at the National Museum of Scotland last year was a discussion with the Keeper of Art and Design and a stakeholder about the sculptural qualities of the copper accelerating cavity acquired from CERN (**Figure 4**). The Rugby Tuning Coil plays a similar visual role in the Science Museum's *Information Age* gallery (Blyth 2015). Other objects have a more intentional visual appeal: my colleagues worked with a participant in the Lothian Birth Cohort trials,

Figure 4: Sculptural science. A radio frequency accelerating cavity from CERN's Large Electron Positron collider, operational from 1989 to 2000, on display in the Enquire gallery in the National Museum of Scotland. T.2014.34. Image © National Museums Scotland.

John Scott, together with clinicians and a laser etching company, to generate a three-dimensional crystal representation of a scan of Scott's brain. We need not navigate the questionable cul-de-sacs of Sci-Art to appreciate the aesthetic qualities of science and technology.

Other emotions are also at play (Geoghegan and Hess 2015). The materiality of science and technology objects, and the patina of use (and abuse), can stimulate powerful nostalgia (Holdsworth 2013). In the case of practitioners, this can be accompanied by considerable professional pride. Long an implicit reason for collecting science, there is no reason not to be overt with visitors about these affective connections, as we are in the case of (other) social history collecting. And, as any colleague who has toured their store with an enthusiast group will attest, these emotions can be stimulated behind-the-scenes too.

Which is not to say that we should restrict ourselves to collecting and exhibiting things that promote warm, fluffy feelings. One area that has received much attention in print is the extent to which we should use science collections to tackle controversy. Within the literature different topics are tangled under this heading. Here I am not tackling exhibitions that become themselves controversial (Lynch and Alberti 2010). Rather, I touch on the capacity of science collections to reveal debate within the scientific community, first noting here that exhibitions can use objects to engage people with contentious issues considered to be at the interface of science and society.

We must now unpack a conundrum: we have long known that visitors like contentious topics (Cameron 2005; Mazda 2004) while simultaneously wanting an authoritative, trustworthy voice. One way to approach this is to present narrative with questions, and to let visitors engage with each other's responses (Carnall, Ashby and Ross 2013). Colleagues at the Norsk Teknisk Museum in Oslo have a track record in provocative exhibitions, on topics such as perceptions of mental health, in which they involve visitors and other stakeholders in formative evaluation and in the exhibition process itself. A recent exhibition, *Grossraum*, is about slave labour in civil engineering during the Nazi era (Treimo 2017). These exhibitions confront visitors with uncomfortable truths – not to provoke for the sake of it, but rather to try to inform and build confidence in their audiences so that the latter can participate in a more informed debate. They hope this will in turn enable visitors to form their own opinions.

As a profession, we curators have a tendency to be navel-gazing, to tie ourselves in knots about what topics are appropriate. But the prominence of contentious topics in the science museum literature (Cameron and Kelly 2010) is not necessarily reflected to the same extent in permanent galleries. This is partly because of the need to ensure they remain valid for a period of decades and partly because of the scale and nature of the support for such large projects. But are we sure this is not also a symptom of our own risk aversion? In the new *Energise* gallery at the National Museum of Scotland we display the control panel from Dounreay (**Figure 5**), the first fast breeder nuclear reactor in the UK. Quite apart from its striking sculptural qualities, it represents what was at the time a new and potentially threatening technology. (Tellingly, it was situated as far from London as possible). Elsewhere we seek to tackle cloning with Dolly the Sheep (1996–2003); but this is not such a hot topic as it was during her lifetime: could we – should we – have done more? Among our very constructive feedback on the energy gallery has been the suggestion that although we display wind farming and other renewable technology, we do not do enough to tackle the climate change debate head-on; we should, and will, do more in this respect within programming and digital media.

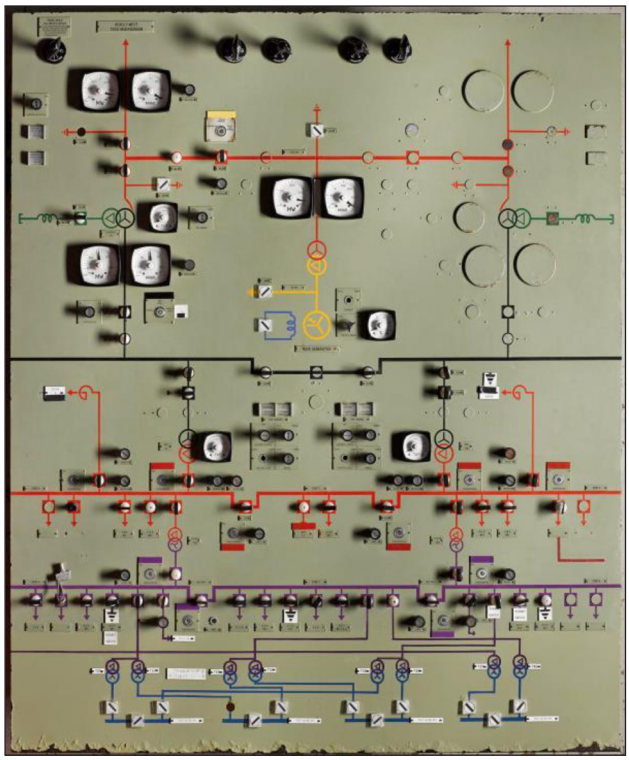

Figure 5: Beautiful controversy. An electrical panel used in the Prototype Fast Reactor control room, Dounreay fast reactor research and development site, Caithness, 1970. T.2015.24. Image © National Museums Scotland.

In relation to these contentious topics, which may be clumsily lumped as debate between science and society, the science object provides an important material hook, and the science museum a valuably neutral space. We can use the object to reveal controversy *within* the scientific community, as I discuss in my final section, which is devoted to programming, events and other activities that are for convenience loosely grouped under the umbrella of 'science engagement'.

To Engage

Sharon Macdonald once asked how science museums were to avoid 'falling prey to the yawn-provoking Scylla of traditional "brass and glass" presentation or the possibly vacuous "whizz-bang" Charybdis of the objectless science centre' (Macdonald 2001, p. 101). This fine line can be walked by using science collections not only in exhibitions but also in education, in programming, in events, and online. These media and activities afford a flexibility that

allows us to extend beyond the comfort zone of resenting science as an established series of discoveries, and into the exploration of the messy business of current, unfinished research (Chittenden 2011; Hine and Medvecky 2015). This involves attention to process rather than product, and an openness about technical dead-ends and conflicting theories (Arnold and Söderqvist 2011).

Few institutions have the capacity to engage with contemporary science via a rolling exhibition; for most it is more feasible to present contemporary developments via events, debates, and digital feeds. The problem is that it is all too easy for the object then to disappear, and the museum becomes indistinguishable from a science centre or a website. The collection is our unique selling point and we can use it to engage our varied users with science, unfinished or otherwise. Users like physical things: educational research demonstrates that a different kind of learning, a different kind of engagement, can be channelled by an authentic object (Anderson et al. 2013; Hampp and Schwan 2015).

The science object should therefore be front-and-centre. An instrument can helpfully act as a boundary object and the museum as a contact zone (although neither concept is unproblematic – see Trompette and Vinck 2009; Boast 2011). That is, physical objects can facilitate communication between groups in the mutually trusted space of the gallery, seminar room or store. And one of the most important functions of the science collection is to bring together practitioners (educator, curator or scientist) with the intergenerational audiences of museums. It may not be possible to inspire all our users, as so many museums pledge to do, but if we can spark the curiosity of only a handful of people, if we can present female scientists as role models for both young men and women (to name one especially important objective), then the object has been put to good use.

For, whether in a formal learning session, a semi-formal event or an informal encounter, the science object can be a hook to explore the social, dynamic, and cultural elements of science. The teamwork involved, the invisible technicians, are too often deleted in museum narratives that focus on the lone genius (Higgitt 2017). I touched on displaying cultural elements of science above; here I want to posit that demystifying the (literal) black box of the science object can demystify the (conceptual) black box of the scientific process. In Edinburgh we seek to use objects from our stores in this way, including for example an Enigma encoding machine (similar to that in **Figure 6**), which we bring out and whose keys can be pressed with careful monitoring – and gloves – by event participants. We also exploit the appeal of working objects, reconstructions and interactives in our attempts to reveal the inner workings and demystify abstruse things (Staubermann 2011).

We should not be afraid to make these encounters fun. Interactivity, games – even (I write with gritted teeth) comedy – can provoke dialogue and reflection. Needless to say, the connections of these approaches to material culture will not always be explicit nor strategic, but they may at least alert audiences to further opportunities to

Figure 6: Opening the 'black box' (in this case, brown). The German Kriegsmarine 'Enigma' encoding machine used in German submarines, 1944, now used in science engagement. T.1994.63. Image © National Museums Scotland.

engage with collections. These events may reach only a fraction of overall visit figures, but it is more than a token fraction, and provides a qualitatively different experience for a number of users. Besides, for all opportunities we stage-manage, many people will encounter science objects inadvertently. In a science museum, parents may bring children for a day out and become engaged themselves; in a multi-disciplinary museum, visitors may stumble upon science collections unintentionally. In the National Museum of Scotland, for example, the copper cavity (**Figure 4**) shines like a beacon to visitors in the adjacent art and design displays. If a visitor passing from Picasso's *Capra* to the Lewis Chessmen stops to think about particle physics on the way, all the better. Science engagement can be serendipitous (Vedder-Weiss 2017); we should think about engagement which *involves* science as well as overt science engagement (Whiteley et al. 2017).

By serendipity or otherwise, these encounters are as likely to be virtual as to be physical. Science collections are increasingly visible online: users of web catalogues, blogs, games, films and social media connected intellectually and visually to our objects may outnumber our physical visitors. Fears that such encounters would diminish on-site experiences have proven unfounded; but are we yet as adept of digital encounters as we might be (although not through want of trying)? And do we often enough take up opportunities to blend material culture with digital media on gallery, or do we fall prey to the inertia of fear of maintenance?

The online potential of science collection points to a more general point about science engagement: that the latter should not be an activity limited to learning

professionals and workflows within the museum, but rather run through all the activities outlined here. (Some) stores can be toured; newly collected material can be deployed in programmes; the research undertaken on our collections can underpin exhibitions (which in turn can stimulate further research). The stakes are high, given the political and economic imperative to enhance science literacy among our fellow citizens. While we may not be able to effect mass change 'science capital' (King's College London 2017), I contend that with blended collections work, research, exhibitions and programming we can generate conversations that would not otherwise have happened.

Conclusion

None of the reasons to collect science presented here will surprise readers of the *Journal of Conservation and Museum Studies*; but accounts of good practice, along with their accompanying literatures, are too often viewed in isolation from one another. Engagement is tackled well by education and visitor studies; exhibitions within museology and art criticism; the results of research outputs can be addressed to specific disciplines (not exclusively history of science, as I have shown); and the embryonic literature on museum stores has yet to find a home. To fully exploit the potential of science collections, as we are trying to show at National Museums Scotland, we need to weave these functions together, to kill several birds with every stone.

Such weaving can be afforded by other kinds of objects; are science collections then as distinctive as we assume? Science is indeed a unique form of human activity – an especially well-resourced and impactful activity – but it is a human activity. Rather than ring-fence it as inviolable, distinct from other museum disciplines, the material culture of science humanizes and connects, and has much in common with the artworks and artefacts in the neighbouring galleries and stores.

The thread that runs through science collections, and the sections above, is their *materiality*. Firstly, such large stores are called for because of the massed physicality of the tools of science; we should celebrate them rather than allow them to be embarrassing afterthoughts, holding-grounds for objects waiting to be on display. Secondly, within the stores, these instruments enables particular kinds of research. And finally, even in exhibitions where they cannot be handled, just as in engagement activities when sometimes they can, the third dimension of science objects gives a qualitatively distinct experience. Even the immaterial and intangible things we should be collecting, cells and software, have tangible manifestations and interfaces – gene chips and hard drives, for example (Söderqvist, Bencard and Mordhorst 2009). We should collect science to embrace its materiality; this is what sets museums apart from other science media.

Unsystematic the above may have been, I tried also to be frank about other reasons to collect to which the science collection is *not* suited. A science collection may not be the best source material for much history of science research. A science collection may not effect a national-level increase in science capital. But I hope also to have reminded readers of the too-often unrealised potential of the science collection: the wider appeal of the store; the capacity for interdisciplinary research; exhibitions that incorporate the history, culture and beauty of scientific instruments; and engagement activities that draw on the above. Just as we can deconstruct the boundaries between science and non-science, so we can dissolve the distinctions between these multiple uses of material culture that are too often considered separately. We should not be thinking about balancing competing functions, but rather blending them. This is why we collect science.

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Competing Interests

The author has no competing interests to declare.

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