Mutability, mobility and meteorites: on some material cultures of the sciences

Simon Schaffer

1st STS Haldane Lecture, 20th November 2014

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on some material cultures of the sciences

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This is the text of Professor Simon Schaffer's public lecture,
delivered on the occasion of the 1st STS Haldane Lecture

MUTABILITY, MOBILITY AND METEORITES

> "In Calcutta there is a violent growth of the cult of Vishvakarnan [Vishwakarma], the god of people who make things with their hands. Machines are decorated with flowers. One is invited to a love feast, caste distinctions gone for one meal at least. Everyone flies kites. Images are made for the Vishvakarna puja and thrown into the Ganga after three days. My wife saw one being taken to the river on an illuminated tramcar decorated with hammers and sickles. It is characteristic of India that you destroy the image with far more ceremony and jollity than you consecrate it. This seems to me admirable. *I should like to see an equally formal and jolly rejection of scientific theories which have served their purpose in focusing attention on something important*. Please don't think I've become a Hindu, but it is time someone talked about the common sense in proletarian Hinduism" (JBS Haldane to Joseph Needham 1951)

Haldane's proposal that the fate of fruitful if failed sciences be marked by the ceremonial disposal of some highly potent object is, as ever, sharply perceptive and its cultural politics ingeniously comparative. This lecture explores a rather familiar example of such change, in this case debates around the question of whether stones ever fall from the sky and leave traces on earth. The aim is to contemplate the cultural fates of objects associated with that transformation. Haldane had some forceful if not always consistent views on meteorites. In his astonishing 1927 vision of the Last Judgment and *life's end*, the possibility that a meteorite would destroy the earth was coolly discussed, and dismissed, while in his celebrated 1929 essay on *life's origins*, he scotched the thought that life might begin thanks to a meteorite. Notions of biogenesis by mossy and mobile meteors had transiently flourished in the later nineteenth century: and, according to JBS, fantasies about spore-bearing extraterrestrial fireballs joined supernatural creationism as consoling illusions that nourished deluded rejection of more earthbound, materialist, experimental accounts of life's origins. A decade later, in his science column for the Communist Party's *Daily Worker*, Haldane gave historical materialists an analysis of how meteorites really worked. Rather than providing a haven for immaterialism, they now taught a lesson in materialist science. 'Shooting stars behave just as you would expect them to on commonsense grounds. That is why, in a country which is running away from commonsense, you read so much about paradoxical particles and so little about shooting stars'.

So the meaning of meteorites was tied up with the politics of commonsense. That's a helpful slogan for this lecture, because what counts as commonsense is extremely mutable and mobile. And fireballs and thunderstones have often violated and dramatised commonsense expectations. A political geography was at stake here. These objects' histories peculiarly involved the definition and management of exotic signs and brutely material objects in a remarkable range of salient sites. It was never simply a question merely of following fireballs/meteors in the sky until they became thunderstones/meteorites on the ground. Their careers did not stop when they struck the earth: an entire serial chain of links, alliances, moves and shifts transmitted fallen stones through very different settings. The complex set of puzzles about celestial matter and earthy minerals, about peasant superstition and patrician imagination, about analytical chemistry and dynamic astronomy, were manipulated in villages and fields, in studios and academies, and, in particular, in cabinets and museums. The materials of these stones mattered enormously: stones such as those analysed in Tuscany in 1794, black segments including reddish pyrites, gray sections with pyrites sand, iron and green glass. These were clues and signs, never decisive or self-evident. 'I believe it necessary to state', wrote a French mineralogist in his 1812 survey of

meteorites' history, 'how often it is difficult for men of science to acknowledge the most evident and the best supported truths'.

Museology, I'll stress, is certainly a good location to try out the mobility and mutability of these things alongside their capacity to turn into brute facts. Curators know that such things are incapable of transmitting a single, sempiternal meaning that survives all their possible uses. But neither are these things so weak that their otherwise protean meaning is completely dependent on every shifting location. There's a common (often disappointed) museological dream, especially in the sciences, that somehow such things could communicate what's tellingly called PUS. The implication is that things are unlikely yet indispensable and eloquent elements in the sciences' show. Hence the continuing puzzle of things as object lessons. In response to his namesake Jules Verne, in 1967 the great Argentinian writer Julio Cortázar composed a collection of stories and reflexions he called *Around the day in eighty worlds*. In a masterpiece of jazzy literary improvisation, Cortázar aimed to show that "there is a world; there are eighty worlds a day". After the British Museum's recent media success, which fascinatingly supposes it's possible to tell the history of the world in a hundred objects, it's perhaps overambitious to attempt the opposite trick: "there is a world", as one might say, "*there are a hundred worlds in each thing*".

Meteorites, aeroliths, fireballs and thunderstones all move through and embody a plurality of worlds. As Haldane's comments show, their fate, in common with other stones, has long figured in the history of thing theories and material cultures. Boswell notoriously related how Samuel Johnson refuted Bishop Berkeley's 'ingenious sophistry to prove the nonexistence of matter: I shall never forget the alacrity with which Johnson answered, striking his foot with mighty force against a large stone, till he rebounded from it, *I refute him thus'*. Turning his own massive body into a kind of philosophical meteor, Johnson could assert materialism by appeal to the base facticity of stony things. His body made the stone talk. That kind of brutal relation between things and facts is the principal concern of tonight's lecture. The opening passages of Jonathan Lamb's invaluable *The things thing say* (2011), devoted to object biographies and this kind of eighteenth-century philosophical materialism, recall that legal and sentimental emotion directed towards a thing might seem the "formalization of a superstition". Lamb points out that Adam Smith's exactly contemporary *Theory of moral sentiments* (1759) explicitly reflected on whether stones might be fit objects of passion, though they themselves "have no feeling". This is precisely how the matter of meteors and falling stones was handled in the cultural geographies of enlightened Europe.

Object biographies are an obvious way of showing how such cultural geographies worked. Thanks to the brilliant work of scholars such as John Burke, Ursula Marvin, Matthieu Gounelle, and Richard Howarth (UCL geologist), it is possible to trace the lives of these stones in great detail. A famous example is a stone weighing about 130 kilos, now preserved in Ensisheim town hall in Alsace. According to a placard that once hung next to it, listing its observed empirical properties, it "has neither taste nor odour. It is blackish, scaly, streaked with white veins, strewn with white and shining grains of a mineral nature. It is of such hardness that in hitting it with steel it bursts out in sparks. No solvent, not even vitriol, affects it, except that it makes it smell of a very fetid oil of sulfur. If it's completely burnt then immediately quenched in water, it is reduced to a powder". This thing is now understood as the oldest surviving west European meteorite. It's reported to have fallen in November 1492, witnessed by one boy, making a one metre hole in a nearby wheat field and seen from across the Rhineland and northwest Switzerland. Three weeks later, the young Habsburg ruler Maximilian entered the town, ordered the

stone hung in the town church, and (correctly) saw its arrival as a sign of his imminent victory over the French and accession to the imperial throne, then (incorrectly) of a successful war against the Turks. This is a thing that started in this world as an eloquent sign.

The Ensisheim stone was celebrated by the famous humanist author of the *Ship of Fools*, Sebastian Brant; described by the monastic wizard Johannes Trithemius; painted by Albrecht Dürer, then in nearby Basel; examined by Paracelsus, who declared it alchemical; and mentioned by the eminent Swiss naturalist Conrad Gesner, who worried about how much had already been removed by souvenir hunters. Swedish destruction of Ensisheim in the Thirty Years' War left it unscathed. A new law graduate from nearby Strasbourg, Goethe saw it in 1771 and "in accord with the scepticism of that time, ridiculed the credulity of mankind", for enlightened sages judged the notion of stones fallen from heaven as popular superstition. In the third year of the new French Republic, 1794, it was peremptorily taken from church to Colmar library, and subjected there to stern examination by the local chemist, Charles Barthold, who analysed its composition (20% iron oxide, 17% alumina), provided the account later printed on its placard, judged it a stone washed from nearby hills, and explained away the local cult as an example of peasants deceived by the glitter of pyrites.

The stone soon hit back. Between 1794 and 1802 Göttingen scholars and London naturalists were impressed enough by the similarity in composition of such stones, whatever their provenance, that they began to guess such things were not local but cosmic. Paris chemists, ordered onto the job, agreed that the Ensisheim stone fitted the type. Back in Alsace, the local historian compiled a catalogue of Renaissance chronicles to back up the new official version and damn Barthold as incompetent. The stone returned to its place over the church choir. Goethe was converted to a belief in the extraterrestrial origin of the stone, and kept a sample in his Weimar cabinet. In 1854 chunks of the stone in New York were used to calibrate samples of the first recorded meteorite fall in the United States, while in 1881, Ensisheim now (temporarily) part of the Kaiserreich, German geologists scrubbed it with soap and water and composed a long drinking song about its virtues: "they scrubbed him thoroughly / and restored to splendour the Prince of the Sky". By 1891 a Yale professor had calculated its original orbit round the Sun. The stone now has its own devoted friendship group, *Les gardiens de la météorite de Ensisheim*, who like wearing red capes and plumed hats on ceremonial occasions. According to one story, not all the thing's in the town hall: a local farmer's reported to use one bit to weight down his barrels of sauerkraut.

Eloquent stones look like superstitious fetishes, things capable of agency and passion. No doubt the Ensisheim stone, entirely alien yet entirely domesticated, belongs to the long catalogue of fetishes that preoccupy devotees of the history of things. Under the regimes of iconoclasm and demystification, fetishes are taken to exert powers that others, who claim superior understanding, deny such things can possess. There's a specific topography associated with these regimes. This is partly because of the received distinction between objects and things: it's as though objects become things when they object. "We begin to confront the thingness of objects when they stop working for us", writes Bill Brown, adding that such fetishism should be seen as a condition for thinking about how "inanimate objects constitute human subjects". Such remarks call for a specification of the places where objects can be deliberately made to stop working for us and misbehave so much they become things to confront and understand. At the late eighteenth and early nineteenth century conjuncture, when such things as the Ensisheim stone moved ingeniously between signs of superstition and relics from the heavens, one of the key places where objects could be made to object was the somewhat newfangled institution of the public

museum collection, decisive in meteorites' fate.

The resonance with the important arguments of John Pickstone on the significance of the novel museological and analytical sciences institutionalised at that moment is clear. In the wake of inventory sciences and globally implemented natural histories, practitioners assembled putatively vast collections, of machines and diseases, of plants and stars, to be conserved and befriended, then subjected to detailed expert analytic scrutiny so as to diagnose their composition and character. As Richard Howarth's indispensable 2006 edited collection on meteoritic history demonstrates, the great public collections established in Vienna, Berlin or London at this period were crucial for the accumulation and judgement of meteorites' nature. In the Habsburg Empire, a private imperial collection set up in 1748 acquired fallen stones from Croatia and Bohemia for the treasury, subsequently transferred to the newly public Naturalien Cabinet that opened in 1766, then massively expanded from the 1770s under its director the mining inspector Ignaz von Born and the assistant director Andreas Xavier Stütz. In similar manner, private teaching collections of such stones stashed in the Prussian Bergakademie were sold to the state for the establishment in 1781 of a novel Royal Mineral Cabinet, a site that accumulated samples worldwide, including Alexander von Humboldt's South American collections in 1807. And during the same few years the British Museum acquired recent samples from Italy and India thanks to the endowment of Joseph Banks in 1802-3 followed by the purchase of his antiquarian colleague Charles Greville's remarkable collection in 1810. Other samples, such as the celebrated Wold Cottage stone from Yorkshire, reached the Museum after a public subscription allowed its purchase from James Sowerby's private museum of British Mineralogy. Fetishes became commodities. One conjecture here is that these museum accumulations made such objects eloquent targets of debate, diagnosis and, ultimately, into the facts of meteoritics. We need to ask how these materials then turned so strikingly into *faits accomplis*.

Fait accompli entered English at that moment as a political expression. It was a state of affairs often achieved by swift power that all protagonists had thence to accept. Such facts signal a matter upon which debate might rely, yet apparently beyond debate. The work of accomplishment is often accompanied by an important redistribution and confinement of power: all subjects are to subscribe to facts that not all have made nor judged. The course of debates on anthropogenic climate change provides a dramatic contemporary public example of how important and hard it is to make things into accomplished facts. Then as now, scientific practitioners at the end of the Enlightenment clearly recognized how important and how complex was the status of *faits accomplis* in establishing their most treasured theories.

There was something like a *crisis of facts* in the late Enlightenment and its immediate aftermath. In public episodes in medicine and economy, astronomy and mechanics, practices till then self-evident were scrutinized, overhauled and in some cases abandoned, while novel principles were institutionalized as natural, obvious and allegedly indisputable. This crisis of facts has been understood as an important aspect of a grave revolutionary imbroglio with both institutional and philosophical implications. Alongside the question of whether stones could fly through the air and fall to earth from the skies, these debates asked such seemingly factual questions as whether therapeutic manipulations carried out by mesmeric magnetisers in their modish séances worked; whether rubbing matter from a smallpox pustule into a scratch in the skin would prevent any further infection; whether the price of grain was best left freely to merchants to fix according to market demand; whether perpetual motion was impossible in principle and if artificial machines were capable of intelligence or reason. In each case, conflicts about

the basis of these facts were entangled with conflicts about the right mode of judgment and the character of the public. In none was the accomplishment unchallenged: mesmerists were judged wrong about the causes of their success, though their efficacy might be confirmed; grain merchants were seen both as agents of economic reason and as conspirators against virtue; inoculation was judged effective but often too risky to implement; the very character of mechanical artifice and its inner workings stayed highly dubious well into the early nineteenth century; and although it was eventually accepted that meteors do crash into the Earth from space, folktales about these events remained moot.

The received categories of popular and specialist knowledges cannot be used to explain the course of these debates, since those very categories were the focus of the controversy. Ron Westrum, whose brilliant 1978 study of the fate of meteorites as anomalies helped define the sociological history of elite and plebeian credibility, showed that these fights' outcomes often retrospectively defined what would count as accomplished facts and who would accomplish them. Some see this crisis of fact and judgment as part of the invention of modern sciences in the revolutionary decades. During this revolution, the enlightenment principle that knowledge of rational natural philosophy be disseminated throughout the social body was simultaneously reckoned a source of public dissidence and uncontrollable debate, as though dangerous mass credulity were the result of general education. During the period of crisis, it was held that public debate required a firm basis, yet it was evident this basis could suddenly shift. This gave *faits accomplis* much of their political charge. Even when treated with fear or condescension, forms of public opinion were unprecedentedly scrutinized and debated.

The late eighteenth century crisis of facts and the museology that dominated meteorites' fate grew out of these polemics about public order in the economy and in institutionalised belief. Enlightened savants launched a major campaign to explain away plebeian doctrines as *superstition*. What had been seen as genuinely dangerous faith in marvels and prodigies became a vast area of learned inquiry. A kind of state-sponsored ethnography set out to collect, document and explain these beliefs. There was a significant change in the meaning of such accusations of superstition or vulgar error during the later eighteenth century. *Superstition* switched from referring to powerful, hostile, alien belief systems, to becoming the label for common, inferior and nonsensical mistakes. But if the plebs were enslaved to superstition and the elite too sceptical, it was held that *imagination* obeyed the opposite social topography: peasants were held to lack imagination, while members of urbane society were imagination's victims.

The map of reliability in the accomplishment of facts could therefore seem remarkably bipolar. *On the one hand*, those who lacked imagination were peculiarly reliable witnesses, invulnerable to the power of imitation or suggestion. In an 1803 analysis of reports of falling stones and fireballs, the Paris physician Joseph Izarn argued eloquently that vulgar peasants were more trustworthy witnesses of wondrous phenomena because they could scarcely imagine uncommon facts. "The more ignorant undoubtedly believe more easily than educated people, but in every fact that doesn't involve an optical mistake, I'd sooner believe an ignorant than an educated person: I might be suspicious of the latter's imagination, while the former has none. And don't urge the preference that's always been remarked in the vulgar for everything wonderful; I know this rather readily happens about *causes*, because they're unknown to them, but as for *facts*, they see them all fine just as they appear, and only take them for what they are: their imagination counts for nothing". But *on the other hand*, it was the elite of enlightened savants who judged themselves the best witnesses, and the most capable of accomplishing facts. Henry Brougham,

later founder member of this College, remarked of Izarn in 1804 that his collection of meteor reports was compelling because it drew both on savants, "very intelligent eye witnesses", and on peasants, "people of less information, indeed, but prepossessed with no theory". Thus the vulgar lacked imagination, so were trustworthy witnesses, but were subject to superstition, so were overly credulous; the elite were peculiarly imaginative, thus vulnerable to the manipulation of charlatans, but invulnerable to superstition, so sceptical, perhaps exaggeratedly so. In his study of the early modern relation between (natural) meteors and (artificial) fireworks, Simon Werrett has shown how elite audiences' alleged capacity to distinguish natural and artificial effects in the display of fireworks and the movement of fireballs was part of a system of social distinction. The demonstrative force required of a publicly accomplished fact was thus entangled with the complex constitution of its enlightened public, whether ideologically inclusive or socially exclusive.

Tales of falling stones long counted as a popular superstition ridiculed by the learned as signs of vulgar error. Even when in 1790 three hundred witnesses in southern France signed an affidavit supporting the existence of such aeroliths, the Montpellier experimental philosopher Pierre Bertholon dismissed such accounts as popular errors that should be treated with pity, not serious study: "how sad to see a whole municipality attempt to certify the truth of folk tales". "Stones fallen from the sky", so it was later said, "relegated to *the collections of some curious persons*, weren't at all examined by the leaders of the modern school, or were only examined with little attention, with the well-formed aim of denying this phenomenon's possibility". In very few years from the mid-1790s learned opinion shifted in favour of the existence of meteorites. In 1793-4, without ever seeing one, the natural philosopher Ernst Chladni sought to accomplish the fact that falling stones were real, fireballs crashed to earth from deep space. His Göttingen ally Georg Lichtenberg told him in early 1793 that just as comets were once seen as mere atmospheric meteors, so now meteors should be seen as cosmic in origin. Chladni repeated this view: "the case with this conjectural theory of mine is the same as with the theory of comets". Much of the theory soon won support from other Göttingen scholars, and his views were rapidly propagated by such journals as the Jena mathematics professor Johann Voigt's *Magazin für Naturkunde* and the chemistry professor Johann Friedrich Gmelin's *Göttingisches Journal der Naturwissenschaften*. But those who criticized Chladni, such as Humboldt, patron of the Berlin museum, alleged he relied solely on folk-tales, not learned analysis. The question of falling stones seemed far from being resolved. Then in the next decade state-sponsored surveyors, the academies' chemical analysts and eminent naturalists all forged an alliance that quickly established that meteors travelling through space generated meteorites witnessed and collected on earth. In such cases, social status exerted within the new spaces of public museums and learned societies helped direct judgments of fact about these recalcitrant and expressive objects.

There was in fact a huge increase in European sightings of meteors in the sky and meteorites on earth once the learned elite accepted their reality and identity. Twenty-five fireballs were reported during the 1780s and 23 during the 1790s: in the following decade this number suddenly trebled. Four falls of stones were reported in the 1780s, just over double that during the 1790s, then the number of reported falls in 1800-9 more than doubled again. Some historians argue this upsurge was the *cause* of savants' change of view about the facts of meteors and meteorites. More plausibly, as Westrum implies, it was a *consequence* of a sudden transformation in their management of factual reports, a usurpation of public belief, especially when we recall the sites of these reports in the periodical network of Europe-

an scholarship and the stones' homes in the cabinets and mineralogical collections of the erudite. Many might witness a fireball, just as Simon Werrett explains how many might witness pyrotechnic shows, even though rather few see stones fallen to earth. In managing this complex project, significant was savants' use of received museological, diagnostic and mineralogical techniques of identification of the stones and quasi-judicial modes of interrogating witnesses. An accomplished fact about aeroliths must rely on linking museum and field in an efficient social network.

Consider the tone of voice used to dismiss testimony of falls. It was argued that the powers of imagination and superstition were both at work. At the same time as Bertholon's condescending dismissal of southern French stories of falling stones, the assistant director of the Vienna Imperial Natural History Cabinet, Andreas Xavier Stütz, analysed peasant testimonies of a shower of stones in Croatia collected almost four decades earlier. Vulgar lack of imagination, "the artless manner in which the whole thing is described" and "the agreement of witnesses who had absolutely no reason to agree on a falsehood" might prompt some faith in these tales. But according to Stütz, recognition of the empire of superstition told against them: "it may have been possible for even the most enlightened minds in Germany to have believed such things in 1751, due to the terrible ignorance then prevailing of natural history and practical physics; but in our time [1790] it would be unpardonable to regard such fairy tales as likely".

When in early 1796 the enlightened journal *La décade philosophique* published an extended account of the southern French reports of stone falls of 1790, its editor the philosopher and economist Jean-Baptiste Say added a note simply denying the facts, "in spite of so much well-affirmed hearsay". Say argued that the shock of a meteorological event would "stun the majority of those that see them…If the tale of a fallen stone spreads, the whole countryside searches for it, and finds a thousand of them: hence those showers of stones that historians report. Must physicists waste their time looking for natural explanations before the facts are beyond doubt?" Even when authors urged the reality of such falls, as did the East India Company physician John Lloyd Williams reporting from Benares in 1802, they also obeyed these conventions of trust: "among a superstitious people any preternatural appearance is viewed with silent awe and reverence" and "we are naturally led to suspect the influence of prejudice and superstition in their descriptions of such phenomena; my inquiries were therefore chiefly directed to the Europeans".

Alongside these rejections of plebeian testimony, the period of the crisis of facts defined privileged sites, places of knowledge that allegedly had the capacity to place such facts beyond doubt or destroy them completely. In London, Joseph Banks' learned empire centred on the Royal Society and the British Museum was one of several systems that helped this privileged geography work. In summer 1794 Banks explained that if "the only witness specified is the peasant at whose feet one of the stones fell and buried itself in the ground", then this was insufficient evidence "for an exact determination of the fact". The President set out the various explanations of these stones that such observers canvassed: the effects of storms and lightning, of volcanic action or samples shifted from nearby rocky deposits. But Banks was sure the authority to decide must be vested in his fellow museum naturalists. Thus samples of so-called "thunder stones" presented to a chemical committee of the Paris Royal Academy of Sciences in 1769 were simply judged pyrites that had been struck by lightning, "however fabulous this kind of fact may appear". The Viennese museum curator Stütz also judged that the Croatian stone had been struck by lightning. Similarly, commenting on the Ensisheim thunder-stone, shifted to display at Colmar in 1793 by French republican officials, the professor Charles Barthold, reckoned that "pyrites' glitter

could have dazzled the people who first found it: ignorance and superstition got mixed up with it, and gave it more value than it deserved and a marvellous existence, violating the fundamental principles of physics". Barthold acknowledged that "in geology and lithology more value than is justified should not be placed on chemical analysis, because it's not enough to know the elementary parts which can be extracted from a rock or a stone", and indeed within eighteen months his analysis was largely rejected by London chemists who saw such rocks as meteorites. Nevertheless, these analytical techniques maintained their restrictive authority over stories from farm workers and peasants.

This authority hinged in large measure on the enlightened confinement of the geography of facts to a specific set of authors and settings. The chemists' museum collections and naturalists' showrooms of the late Enlightenment were touted as those institutions which could uniquely make and show delocalized, potentially universal, eloquently staged objects. These materials' work as delocalized global indicators was helped by their linkage through a rather tight network of publication established during the media revolution of the later eighteenth century. Academic journals and circulating periodicals from London, Paris, Göttingen or Berlin carried swift news of the work the savants conducted on these puzzling stones and fireballs. This is why the establishment of meteorites' reality as a *fait accompli* by 1803 was rather rapid and dramatic, though certainly not uncontroversial, and why reports so dramatically increased in number in the wake of this usurpation.

In important cases, the accumulation of highly prized specimens at central sites was supposed to help make authoritative facts possible. Suppliers and savants both knew this. In 1794, soon after Chladni's first announcement of his theory of meteorites, it was reported from Tuscany that stones collected there after a reported fall had in fact been faked by locals to sell to curious travellers. When comparable samples gathered in Yorkshire were shown in a London display in summer 1796, accompanied by a souvenir handbill carrying the stone's picture and witness statements to its fall from the sky, "many learned men of the day" used the occasion to condemn "the blind credulity of the public". Banks at once spotted the similarity in the Tuscan and Yorkshire field reports. He feared this was "*an imitation meant in this case as an attempt to ridicule the credulity of naturalists*". His close friend the chemist Edward Howard agreed: "the exhibition of this stone as a sort of show did not tend to accredit the account of its descent". The exhibition encouraged journalists to fill their pages with stories of remarkable fireballs and falling stones. In London during autumn 1796, the *Gentleman's Magazine* carried several such stories of the "regular judicial manner" in which reports of falls from Tuscany had been gathered and the Yorkshire events recorded, alongside various accounts of apparent "extinguished meteors". But this was not yet enough to sway enlightened writers: "we cannot agree in the propriety or probability of multiplying lying miracles on ordinary occasions, for we see not one extraordinary occasion among all that are here recited, nor is the evidence of a few peasants or women to be admitted on these occasions".

Much more decisive were official efforts to accumulate, juxtapose and analyse both testimonies and samples at the museological centres of enlightened sciences; then to mobilise the network of journals to establish the reality of meteorites as an accomplished fact. In 1797 Chladni argued that resistance to the reality of meteorite falls was due to public prejudice: "people have not been accustomed to it, or on account of the rarity of these phenomena many facts of this kind have been denied or have escaped notice". But the rapid changes in elite consensus on thunderstones and meteorites were accomplished not by more vulgar testimony, but rather by the collections managed by the Banksian learned empire in London and the Laplacian regime in Paris in 1802-3, followed up quickly by transmis-

sion through the European publicity system. Between 1800 and 1802, as we've seen, Banks' global network of accumulation assembled an unrivalled collection of samples, including those from Tuscany and from Yorkshire, Williams' stone from Benares, and the impressive European collections of Banks' antiquarian ally Charles Greville. Where Banks' suspicions had been raised in 1796 by *the similarity of field reports* about falling stones, from 1800 he actively encouraged *analytical-diagnostic demonstration* of the similarity of these stones' mineral composition. All these specimens were passed to Greville's colleague and eminent mineralogist the Comte de Bournon, and to Banks' client the aristocratic chemist Edward Howard. In early 1802 the two noble analysts announced at the Royal Society that despite these samples' widely distributed provenances they shared common features, nickel and iron alloys encased in blackened oxidised iron crusts. Though Howard and his colleagues doubted that meteorites came from fireballs, preferring an electrical model of their origin, they firmly established the stones' extraterrestrial source. Howard pointed out that his argument was entirely independent of field testimony, and entirely dependent on diagnosis within the museum, since "to those who disbelieve what they cannot explain it would be fruitless".

European journals rapidly transmitted these views to the network of enlightened readers: Chladni's papers were republished in London in 1798-9; the Geneva astronomer and naturalist Marc-Auguste Pictet, editor of the *Bibliothèque britannique*, came to London to meet Banks and Howard in early 1801; and in 1802 French versions of the work of Howard and Bournon appeared both in the *Journal des mines* and the *Journal de physique*. By no means all savants were won over by the Banksian stories of falling stones. At the end of 1802 Eugène Patrin, mineralogist and librarian at the Paris School of Mines, declared that multiplying wonders such as falling stones was merely a way of winning public applause and that the idea of falling stones "was once a received opinion, but perfected physics seemed to have made this supposition vanish forever". Patrin used the most traditional enlightened resources against such superstitions: he decried the status of witnesses such as ill-informed Indians and pointed out that much was taken as a *fait accompli* even when its cause was unknown. Soon the elderly Swiss naturalist Guillaume-Antoine Deluc, who'd heard Howard's paper at the Royal Society, also asked "how many facts there are that no-one doubts, even though they can't be explained or else explained in a very uncertain way". Armed with a superb private museum collection of igneous rocks, he urged the volcanic origin of such stones and judged the problem "now entirely enlightened". Following Patrin, he denounced the credulity of "Siberian tartars" or "Yorkshire labourers": "I leave it to be judged by posterity what faith should be vested in reports based solely on fantasy or the ignorance of the first who spotted them". While Deluc's ferocious opposition to the reality of celestial meteorites was certainly in part due to his Calvinist loathing of fashionable naturalistic and materialist cosmologies, his views and those of his allies were widely distributed in the European journals.

In response to these criticisms, expert French and German chemists largely replicated the London analysts' findings. More decisively, the Paris regime complemented them by extending a new kind of discipline to its fieldwork. French academicians and curators worked deliberately to transform the facts of falling stones from rural superstition into unarguably public, enlightened events. In summer 1802, in direct response to the London chemists' results and Williams' Indian report, the new young physics professor at the Collège de France, Jean-Baptiste Biot, published a statement in their support distinguishing between "an extraordinary fact reported by trustworthy people" and any "supernatural" fact, which must be rejected: "peoples' agreement doesn't give any weight to this, because the people are disposed

to believe everything". In late 1802 he followed this with a Laplacian analysis showing the physical possibility that meteorites could reach Earth from the Moon. When reports reached Paris in spring 1803 of a fall of stones in lower Normandy, the Institut's chemists showed these samples' composition was akin to those in Howard's report. But, more significantly, Biot was soon sent on mission to gather specimens, collect testimony and determine the facts. As Ron Westrum and Matthieu Gounelle sagely note, Biot's aim was not to gather testimony but instead, as a metropolitan delegate, to displace it. Unlike Bertholon's dismissal of hundreds of witnesses of falls in southern France a decade earlier, Biot expertly made himself into *the representative* of the Norman community: he stressed their "condition and moral qualities", recorded his sources among "enlightened workmen", and sought to "bring together these stories made by enlightened men with those gathered in the countryside".

Just as Williams in colonial Benares relied on European administrative networks to gather testimony of a meteorite fall at the end of 1798, so the Parisian delegate in 1803 used the political system of educational reform, administrative rationalisation and statistical scrutiny established by the imperial regime in the French provinces. Despatched by the Ministry of the Interior, he drew on crucial resources from metropolitan savants, and in Normandy worked with the prefect, engineers, schoolteachers and local experts. He also applied geometrical analysis to define the scope of the fall and its plausible origin. Back in Paris, stone samples from Normandy were successfully displayed in cabinets and showrooms: unlike the comparable display of Yorkshire samples in London in 1796, they were no longer treated as signs of popular credulity. Instead, Biot's administrative report of his scientific expedition, presented to the Institute and the minister, was a *fait accompli*. Any official doubt of the extra-terrestrial origin of falling stones swiftly ceased.

In London and Paris in 1802-3 the exercise of considerable administrative and exhibitionary power over long-range phenomena and people effectively closed the question of meteorites' reality. A restrictive model of enlightened reason aided the exercise of such power, then aided the speed and scope of this *fait accompli*. Of at least equal interest, these institutions then at once went back over the prior history of the debate, performing a kind of political and material archaeology to explain how what now was seemingly obvious truth had ever been in doubt. In answer to the elite's long denial of stories of falling stones, the chemical mineralogist Bournon declared against Patrin that the fact of stones' fall "has always been rejected without sufficient examination and for the sole reason that it derived from men's love of the marvellous, and didn't deserve the attention of those whom a healthy philosophy sheltered from this error". Thus the history of enlightenment materialism was entangled with this retrospective explanation of how an accomplished fact had for so long been denied. It became common to compare the *fait accompli* of meteorites' reality with the sudden changes that had allowed Benjamin Franklin to demonstrate the safety of lightning rods or Antoine Lavoisier the composition of water: "we ourselves recently, in refusing the evidence and testimonies of all peoples, set the fall of stones among the most absurd popular prejudices". Writing in the *Edinburgh review* in 1804 Brougham, similarly reflected on how many well-supported testimonies, including those presented to Bertholon from southern France, had been "treated by the naturalists near the spot with perverse incredulity".

Surveys of meteorite collections and their provenance therefore persistently stood "astounded by the pyrrhonism of the savants, who for so long refused to give in to the evidence and to use the means science placed in their hands". This auto-critique offered the paradox that once the fact of meteorites was recognized, it must also be recognized that in the event, as Brougham put it, "credulity has been

more philosophical than scepticism". The price of such remarkable usurpations was thus the difficulty in explaining how an accomplished fact had never before been recognized as such.

These stones became things whose understanding included telling tales about how understanding had changed, and should properly change. In the later nineteenth century, as is well known, eminent scientists such as William Thomson and Hermann von Helmholtz lectured on the possibility of "countless seed-bearing meteoritic stones" helping generate life on earth, while Joseph Dalton Hooker at Kew insisted that "I would as soon believe in the Phoenix as in the meteoritic import of life". In 1879-80 a German lawyer Otto Hahn, trained in geology at Tübingen, released a series of highly contested publications carrying images resembling fossil sponges and corals made from thin sections from a celebrated chondritic meteorite that had fallen in Hungary in 1866 and thence preserved in the Vienna museum. According to the pre-eminent zoologist Carl Vogt, 'one does not know at what to be most astonished, the author's complete ignorance of the laws of evolution or the audacity with which he presents his views in terms worthy of the oracle of Delphi'. Unabashed, Hahn sent Charles Darwin these images: and allegedly got the great naturalist's astonished approval. The UCL geology professor Thomas Bonney was horrified by this apparent approval, but then delighted in early 1882 when Darwin denied Hahn's story. Material analysis, public news and the issues of fact making were long tangled up together around the stones. The material cultures of such sciences always involve this kind of simultaneous definition of the public and its status, and of the thing and its career.

This story started in a museum, and finishes in one. Scientists work exceptionally hard and collaboratively to give things like aeroliths singular meanings, to make golden events, smoking guns and unchallengeable facts. But the stones won't stay still. Some contemporary meteorite scientists associate the Hahn episode with much more recent projects about chondrites, organisms and the stones' meanings. The twentieth-century career of meteorite ALH84001 and its implications for alien life show how these changes work. After 4 billion years beneath the Martian surface, 16 million years in interplanetary space, 13 millenia in the Antarctic, eight years of misclassified storage as a piece of diogenite in a curatorial fridge in the Johnson Space Centre Houston, and then two years' hard collaborative work by geologists, chemists, spectroscopists and exobiologists, this rock appeared at a press conference on 7 August 1996. The performers there pointed out the carbonate rosettes in the meteorite, surrounded with polycyclic hydrocarbons and, where the carbonates had dissolved, magnetite crystals of characteristic shape. They added that there was electron microscopic evidence of nanofossils. Four elements of a story, then, each separably defeasible, but in combination suggesting a tale of early Martian life. Simple journalistic enthusiasm about the possibility of life on Mars was to be expected. Political exigencies and funding crises at NASA help explain the verbiage of re-election candidate Bill Clinton: "Rock 84001 speaks of the possibility of life. Its implications are as far-reaching and awe-inspiring as can be imagined. Even as it promises answers to some of our oldest questions, it poses still others even more fundamental. We will continue to listen closely to what it has to say as we continue the search for answers and for knowledge that is as old as humanity itself but essential to our people's future".

This eloquent thing deserved location in a museum. But whose understanding to trust? In late 1996, Vice-president Al Gore convened a major conference to discuss the implications, including more cash for exobiologists. Shows for a wider public often express more security than debates within a specialist community. The NASA team's leader told the press conference that "this is a controversial story and there will be lots of disagreement". He was right. William Schopf, a UCLA palaeobiologist, publicly

doubted that organic remains in the meteorite could come from biological processes; noted that colonies of classic cell reproduction had not thus far been located; and pointed out that the researchers' 'microfossils' were implausibly small. Is the shape of its much--vaunted magnetite crystals a sign of life? "Shape is one of the worst things you can use in geology to define things" said the Washington State geologist Everett Shock. Interviewed in a fine BBC Horizon documentary on the meteorite controversy, Schopf declared that "science is not in the belief business", and that for such high stakes "irrefutable evidence" is indispensable. Yet here belief and its refutation were clearly the very stuff of the lived process of contemporary sciences. Richard Zare, a Stanford chemist in the NASA team, wondered "who is to say we are not all Martians?' Who indeed? So there's a basic condition of how such things function. The social order's problems, and those of mobile and mutable objects, get fixed together.

So to understand meteorite ALH84001—an unremarkable if alien rock or the key to human destiny - needs a choice between different stories and that choice would change the object's sense. These stories include long histories of elite attitudes to meteorite samples, narratives of space exploration, including the 1976 Viking missions which seemed so decisively to rule against a habitable Martian environment, stories which looked forward to the Martian Global Surveyor of 1997 (Clinton was careful to note that its scheduled arrival is the Fourth of July), stories which look backward beyond the location of the meteorite in early 1984 to Ensisheim in 1492. On even the most restricted version of this rock's sense, we may wish to draw attention to the funding implications for NASA and the Russians, to the role of geologists in amassing meteorite samples, to the possibility of extraterrestrial life, or to the high-tech skills of spectroscopy and electron scanning microscopy. Each story and each setting suggests rather different attitudes to the rock in question and the means to be used to display its meaning, and each also links up with different relations of authority and trust, expertise and belief.

In the event, the Allan Hills meteorite has not been able to convey a firm message about Martian life, but speaks clearly about the life of scientific understanding and scientific materials even though, and precisely because, it has not even yet, two decades later, quite been decided whether this is evidence of Martian life or merely of Houston's ingenuity. Museums seeking a fixed understanding of this eloquent thing would no doubt find ALH84001 useless or distracting, not at all yet fit to tell its tale from behind a glass-fronted case. They might find it hard to see how the rock could possibly get a speaking part in a complex museological story of exclusive and contradictory parties to alien life. This is perhaps because of that old faith that things are only understood, and only help understanding, when they speak univocally and unambiguously, when they can be entirely trusted. But mobile and mutable things nevertheless do help define the standing of all the different agents who have a stake in their understanding. These differences then play decisive roles in what that understanding is. Expert on the origin of alien and earthly life, Haldane told the readers of the *Daily Worker* in 1939 materialism was a programme for effective mobility and mobilisation: "neither the form of the landscape nor of society is fixed. Mountain ranges may sink under the sea and autocratic empires become people's republics. The laws which govern these changes can be discovered and these discoveries can be used." As he later insisted, *every thing has a history*. These historic mobiles are a few of my favourite things because, properly located, they help us better understand the plurality of worlds.

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