Rifer Sanedrio) wrote in 1680 about the Miocene vertebrate site of Concud (Fig. 5a–c), located close to what would become the eponymous strato-type locality for the Turolian continental stage: 'Near Teruel, in a place called Concut (Concud), you will see that the ground is breeding, in a part of the mountain, bones and skulls of men, as well as in other grounds grow herbs and plants' (Ferrer de Valdecebro 1680; Alcalá 2012). This indicates that Lhwyd's ideas were far from unique in a world struggling to understand these curiosities from the rocks.

As significant as Lhwyd's work was – and it was seized on by others in his 'lythoscoping' community,

(a)

(b)

Fig. 5. (a) The area of Concud (Teruel) cited by Ferrer and Feijoo; image courtesy of Comandancia de la Guardia Civil de Teruel. (b) Locality, during visit of the European Association of Vertebrate Palaeontologists' 2012 field trip led by LA; image courtesy of JJL.

(c)

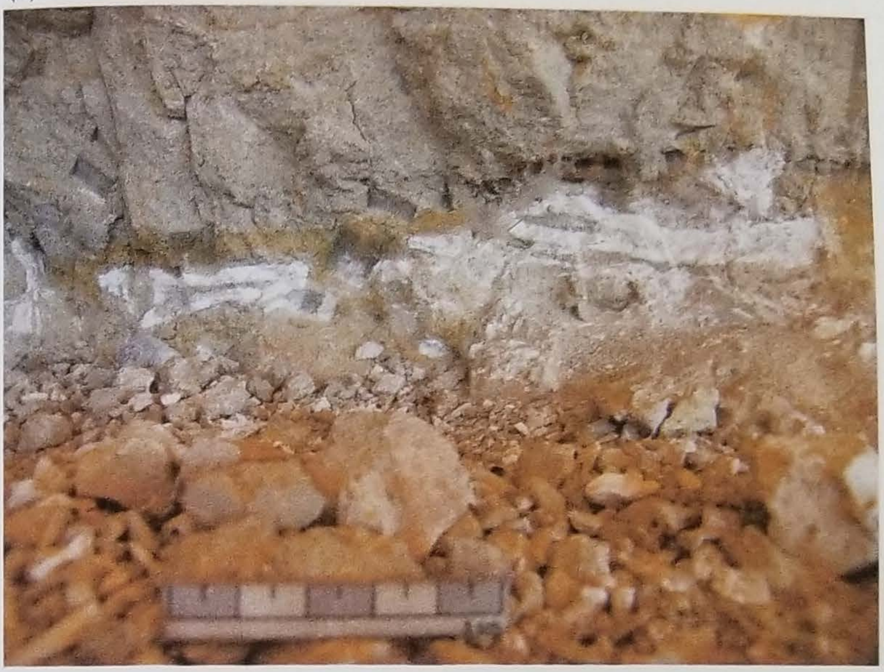


Fig. 5. *Continued.* (**c**) Close-up of bones *in situ*; image courtesy of JJL.

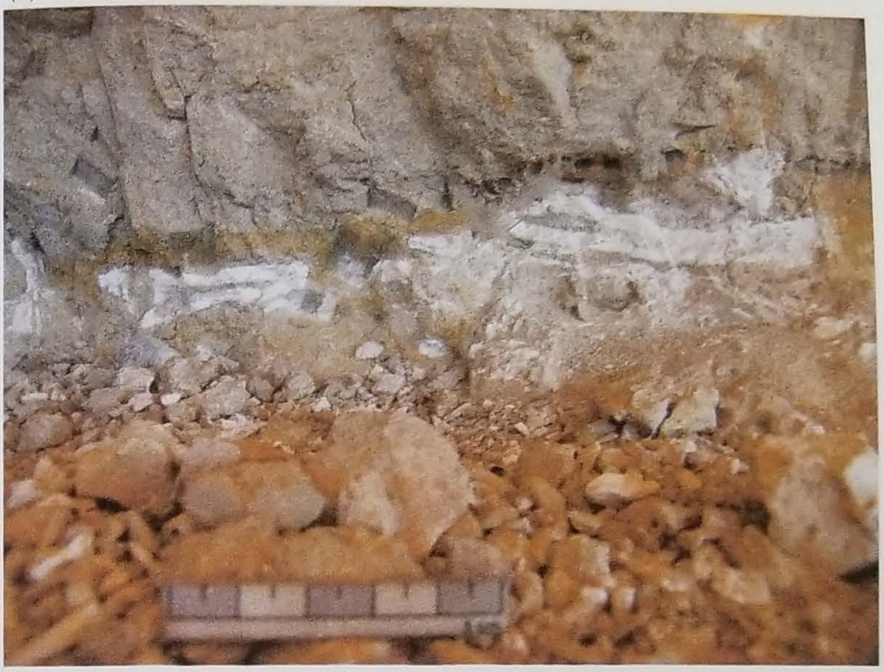
such as Robert Wodrow in the University of Glasgow (1679–1734; Liston 2012*b*) – it had the disadvantage of being in Latin. By virtue of writing in English, John Woodward (1665–1728; Fig. 6a) was more accessible and therefore had greater influence. He was Professor of Physick (i.e. medicine) at Gresham College London, and founded the first Chair of Geology in Britain at Cambridge University which he had received his medical degree from (Porter 1979). As such, Woodward was another example of the overlap between medicine and early palaeontology; unlike Hunter and Parkinson, however, he was able, by dint of his alma mater, to become a member of the Royal College of Physicians. Woodward, like Wodrow, was a diluvialist, but there was a significant difference in their approaches to fossils. Like Wodrow, Woodward had no problem with the idea that fossils were the actual remains of living organisms. Indeed, Woodward invoked the belief of others that fossils were merely generated in the rock like the seeds related by Lhwyd and Ferrer as one of the stimuli that provoked him to write his 1695 'Natural History of the Earth', which is regarded as having finally ended debate about fossils being mere 'sports of nature' (Porter 1979, p. 337):

> It must be allow'd, that I had the more Reason to attempt the *Natural History of the Earth*, and of the Bodies found in it, both *native* and *extraneous*, because, as you observe, this Study had all along lain in the greatest Darkness and Confusion: And, to the very Time that I set forth that Work, it was *not yet agreed among the Learned, whether these Bodies formerly call'd* Petrify'd Shells, *but now-a-days passing by the Names of formed Stones, be original Productions of Nature, form'd in Imitation of the Shells of Fishes, or the Shells themselves*. Indeed the latest Writers of all were positive that these Bodies were not *real* [Ray 1693]. Dr. *Lister* asserts point blank they were *never any part of an Animal*, being only *Resemblances of Shells*, but *meer Stones*, which the *Earth produces*, and each *shap'd by the Power inherent in the Stone*, or in it self. This must needs be allowed by all who made any Observations of the Productions of Nature in the Formation of Bodies, tho' they have not made many Observations on these, to be a Doctrine, however positively delivered, very mysterious and paradoxical' (Letter III to Sir John Hoskyns Baronet, Woodward 1728*a*, pp. 25–25).

John Woodward's 'Fossils of all Kinds, Digested into a Method, Suitable to their mutual Relation and Affinity' and his 'A Catalogue of the Additional Extraneous English Fossils', the first featured specimen of which was a megalosaurian limb bone (specimen number A1, Delair & Sarjeant 1975), were both published posthumously in 1728 (Woodward 1728*a*, *b*).

Woodward's collection of just under 10 000 specimens went on to form the core of what is now the Sedgwick (formerly the Woodwardian) Museum, and within them was the palaeontological collection of Agostino Scilla (1629–1700), acquired between 1700 and 1717. Scilla's views as expressed in his 1670 'Vain Speculation Undeceived by Sense',

(c)



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(a)

(b)

8 *Letters relating to*

and ſet forth by the Writers of Natural Hiſtory, under the general Name of FOSSILS.

THESE are of two Sorts, *extraneous*, and *native*. By *extraneous Foſſils*, I intend the various *vegetable Bodies*: As likewiſe the *Teeth* and *Bones* of *terreſtrial Animals*, and the Shells of *Oyſters*, *Conchæ*, *Cochleæ*, *Echini*, and other marine Creatures, that are found in great Numbers and Variety, buryed in all Parts of the Earth. Theſe, by moſt late Authors, have been ſuppoſed to be found in the Earth, and meer Stones; and treated of as ſuch, under the Names of *Oſtracites*, *Conchites*, *Cochlites*, and *Echinites*; which Names occurr very frequently in the Writers of Foſſils. And, by thoſe Names, ſometimes they deſign meerly the Shells above recited; ſimple, free, and empty: Sometimes thoſe Shells fill'd with Stony, Flinty, or other like Matter: Sometimes only the Stone, Flint, Spar, or other Mineral Bodies, that were originally formed and moulded in thoſe Sorts of Shells, ſince periſhed

the Method of Foſſils. 9

and gone: Sometimes the meer Impreſſions of them in Stone: And not uncommonly, all theſe promiſcuouſly and indifferently. Which want of Care, and due Examination of theſe ſo different Bodies was indeed one great Cauſe that thoſe Writers fell into that Opinion. But the ſeveral *Sorts* of them are now rightly diſtinguiſh'd [a], and the *Origin* of each aſcertain'd [b].

I ſhall only add here, for the further clearing up of this Matter, the ſeveral fanciful Names that have been heretofore given to ſome of the moſt remarkable of theſe Bodies: And, from my own Obſervations upon them, note what they really are. That commonly call'd *Cornu Ammonis* [c] owes its Form to a turbinated Shell: The *Bucardites* [d], to a *Bivalve*. Indeed both of them are frequently found actually covered with the very Shells in which they were formed. That Body to

K which

[a] *Catalogue of the Foſſils of England, &c.* M. S. [b] *Nat. Hiſt. of the Earth*, Part 4 and 5. [c] Plin. xxxvii. 10 [d] Plin. ibid.

the Method of Foſſils. 13

England, chiefly in the Chalk-Pits in *Surrey* and *Kent*. Mr. *Roſinus* calls the *Stachyoides*, Foſſil *Sea-Stars*, I confeſs I cannot imagin for what Reaſon. The *Parts* and *Segments* of theſe Bodies have obtain'd various Names among the Writers of *Foſſils*, e. gr. *Encrinos*, *Pentacrinos*, *Pentagonos* [x]. The Bodies call'd by Mr. *Lhwyd Stellariæ* [y], are no other than Parts of the *Stella Arboreſcens*. The *Gloſſopetræ* are Teeth chiefly of *Sharks* of various Kinds. The *Plectronitæ*, or *Roſtrage* of Mr. *Lhwyd* [z], is the Tooth of a ſtrange Sea Fiſh, not nam'd nor deſcrib'd by the Writers of Fiſhes. There is in my Collection, a Jaw of this Fiſh digg'd up, with Teeth of this Kind ſtill actually remaining in it. The *Bufonitæ* are Teeth of the *Wolf-Fiſh* digg'd up in many Countries, along with other Spolia of the Sea. Theſe were wont formerly to be worn in Rings, and pretended to have grown in the Heads of *Toads*, whence they had the Name of

Bufonii,

[x] Lachmund de Foſſ. Hildeſheim. *Sect.* 5. *c.* 17. 18. [y] *Lithol. Brit.* Tab. 14. [z] Lithophylacium Britan. Tab. 16.

Fig. 6. (**a**) John Woodward (1665–1728). Mezzotint by W. Humphrey (Wellcome Library, London). (**b**) An extract from his 'Fossils of all Kinds', where he dismisses new names for fossil material. Contra Woodward, these are the current interpretations of these names used by Lhwyd: *Ichthyospondyli* (ichthyosaur), *Ichthyodontes cuspidate* (shark's teeth: *Odontaspis, Lamna, Notidanus, Hybodus, Carcharodon*) plus pycnodont (*Gyrodus*), *Ichthyodontes Scutellati* (marine reptile, shark) includes *Glossopetrae* (shark's teeth e.g. *Hybodus* and *Carcharodon*), *Plectronites* (pliosaur), *Rostrago* (marine crocodile), *Rutellum implicatum* (sauropod), *Siliquastrum* (*Strophodus*), *Limaculum* and *Radius minimus* (*Acrodus*), *Bufonites scaphoides* (pycnodont), *Maxillaria* (chimaeroid, *Ischyodus*), *Bufonites orbiculatus rugosus* (*Gyrodus* tooth) and *Bufonites ad pisolithos accedens* (*Gyrodus* tooth).

which Woodward must have been aware of, very much chimed with Woodward's, but more mockingly criticized the idea that fossils formed within the rocks:

> '... blind folly not to realise that it would have to start with another, perfectly composed stone body, already in that shape, over which many fine layers were laid down so as to produce the alleged configuration. What a hallucination to affirm that it was all due to chance, or to some subtle generative virtue composing Nature's jokes and shutting them up in rocks! What piffle! These shellfish lived in water and then rotted: a joke of time, not of Nature' (Pemberton *et al.* in press, p. 84).

Similarly, in 1736, the Spanish Benedictine monk Benito Jerónimo Feijoo, referring to the fossil bones and teeth of Concud, argued that they were not just curious configurations:

> Whoever believes that this regular pattern, faithfully observed in many thousands of stones, was the effect of a chance, is willing to nod to Epicurus, that all bodies of the Universe are effects of the fortuitous concourse of Atoms ... Think upon this part as is wished, we have given evidence enough that those remains were not originally stones, but bones (Feijoo 1736, p. 30, 32).

Concud is today the flagship locality for the continental Turolian.

A key difference between Woodward and Wodrow was that Wodrow used fossils to try to find evidence of the Flood, whereas Woodward presupposed the Flood to be an established fact in order to explain the contemporary distribution of fossils, arguing that the floodwaters had produced the horizontally stratified rock layers (Liston 2012*b*). This however meant that the fossils that were found had the context, within Woodward's paradigm, of being all subsequent to that catastrophe. It is therefore an apparent source of irritation to him that researchers were giving special names to fossil forms, rather than simply utilizing contemporary nomenclature for extant animals. He goes on at some length about this, clearly not doubting himself as less than the single authority on the subject:

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In addition to Lhwyd, Woodward proceeds to attack Ole Worm for similarly attempting to establish what he regarded as superfluous names (Hoch 2013). This seems to have been typical of his attitude to most of his peers, even going as far as duelling with his rival, the physician Richard Mead (1673–1754), who seems to have inspired William Hunter to imitate his wide-ranging collections (Porter 1979; Liston 2013).

Wodrow wrote on the theories of Ray and Lhwyd in his correspondence, gently chiding Woodward for advancing a hypothesis of 'unreasonable fancy' when 'we are not ripe for raising hypotheses as yet...we want observations and experiments sufficient to found theorys on' and dismissed Woodward's simple adherence to dogma in this regard (Liston 2012*b*, p. 422). As noted by Lewis (2009*a*), Lord Bute (a friend of William Hunter and a key player in the initiative to establish Hunter's public museum of anatomy in London while Bute was First Minister of the Treasury in 1763; Liston 2013) also criticized John Woodward's observations as being too limited and hence parochial in their conclusions: 'the author sees every thing in one light, and shuts His Eyes to all Phenomena that make against this darling child of his own production' (Stuart 1782, p. 12). 'He seems so thoroughly convinc'd of the truth of His Hypothesis, that he often neglects giving reasons for many of his assertions'.

Organic remains of a former world

Given these examples of the thinking prevalent at the time, and the dearth of publications around for the general enthusiast, Parkinson's endeavour becomes pioneering: what he attempted to do was to pool the global knowledge of fossil material and present it in an accessible form in one place. Thackray notes early 1801 as the time when Parkinson decided to write the books, publishing a notice requesting assistance through letters, drawings and specimens, although he had been noted at sales for fossil material since June 1798 (Thackray 1976). In commencing his great task, Parkinson began to acquire fossil material on a larger scale to enhance his collection, as well as using the British Museum collections. The first volume had been published by June 1804, featuring descriptions of fossil plant remains from around the world as well as from within his own collection, figured on nine colour plates (Thackray 1976). To fit with its popular intended market, the work was laid out as a series of 48 letters between a novice and an authority, a not unusual style for the time (Lewis pers. comm. 2016). Parkinson moved from his fictional persona which Woodward must have been aware of, very much chimed with Woodward's, but more mockingly criticized the idea that fossils formed within the rocks:

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Table 1. *The use of earths for medicinal purposes through the ages*

Medicinal earth (English/Greek)	Hippocrates (fifth century BC)	Dioscorides (first century AD)	Galen (second century AD)	Hans Sloane (eighteenth century AD)
Aegyptiae/Αἰγυπτίη	K II 561 (Π: IV 416)	K I 778	K XII 177	T IIIa 175
Armenia/Ἀρμενικὴ βῶλος		K I 788	K XII 189–192	**T** IIIa 133 off; 155; 168 Bolus vulgar. Off.B.
Eretria/Ἐρετριάς	K II 319 (Π: IV 274)	K I 821	K XII 188	
Samia/Σαμία	K II 557 (Π: IV 412)	K I 822	K XII 178–9	T IIIa 169
Chia/Χία		K I 823	K XII 180–181	
Kimolia/Κιμωλία		K I 824	K XII 182	T III 167 off.
Lemnia/Λημνία		K I 778–779	K XII 168–176	147–8 off., 169–170 off. 182, 184, 186, 187, 193,194
Melia/Μηλεία στυπτηρίη	K III 315–322 (Π: III 504)	K I 825		

Citations to Kühn editions of *Opera Omnia Graecorum* are denoted with the letter K followed by the volume in roman numerals for the corresponding Greek author, followed by the page number. The Greek letter Π denotes the Greek edition of Hippocrates by G. Pournaropoulos (Martinos publisher, Athens, 1967–71) followed by the volume in roman numerals and page. T under Hans Sloane denotes the volume in roman numerals of his manuscript catalogues followed by the item listed. Off denotes 'officinale', i.e. for medicinal use.

XII; p. 168). He recognized several properties of earth including one that is 'greasy' and which, when mixed with water, becomes viscous clay.

According to one version of the myth, the Homeric hero Philoctetes, a famed archer, was treating himself on Lemnos for a gangrenous wound on his foot after a snake bite, applying the soil of the island onto the ulcer. Galen visited Lemnos twice in order to ascertain the method of processing the island's earth into sealed troches (the pleural of trochos emanates from the Greek τροχός (wheel) or τρόχισκος small wheel) by the priestess of the temple of Artemis (Galeni de simplicium medicamentorum temperamentis ac facultatibus liber IX, *in* Kühn 1826, XII; pp. 165–178).

Galen, clearly impressed, left the island taking with him an ample supply of troches (20 000!) for his illustrious patients in Rome. He confirmed the therapeutic properties described by Dioscorides and added that he used the sealed (Sigillata) earth successfully for viper bites and on malignant ulcers (Retsas 2012).

According to Galen, apart from its therapeutic merits when used as a single agent, the famed (πολυθρύλητος) Lemnian earth was also an important component of *theriaca*, an antidote containing some 60 or so additional components. In addition to his books on antidotes, Galen dedicated two books to *theriaca* (Nutton 2004, p. 246). An experimentalist (Retsas 2010), he also conducted a trial in order to ascertain the efficacy of this antidote against viper bites. He experimented with two groups of cockerels, but he does not tell us how many animals were included in each group. Both groups were exposed to viper bites; the group that was fed with *theriaca* beforehand survived, whereas all the animals in the no-treatment group died after they were bitten. Was this perhaps the first attempt to conduct a controlled animal experiment? (ΓΑΛΗΝΟΥ ΠΡΟΣ ΠΙΣΩΝΑ ΠΕΡΙ ΤΗΣ ΘΗΡΙΑΚΗΣ ΒΙΒΛΙΟΝ *in* Kühn 1827, XIV; p. 215).

Recent analyses employing modern technology (X-ray diffraction analyses) indicate that the dominant components of the Lemnian earth are montmorillonite, kaolin, alum and haematite (Photos-Jones & Hall 2011, cited in Paximadas 2014).

According to Thompson (1914), the Terra Sigillata was included in the first edition of the *Pharmacopoeia of the Royal College of Physicians of London* printed in 1618 among the ingredients in the treacle of Andromachus; its last appearance in any important work on pharmacy was most probably in Grey's Supplement to the *Pharmacopoeia* of 1848.

Rufus of Ephesus used the Cimolia and Eretrian earths for the treatment of gonorrhoea and satyriasis, applied for their cooling properties on the perineum and penis. (ἀμβλύνει γὰρ τὰς ὁρμὰς τοῦ μίσγεσθαι, εἴπερ τι καὶ ἄλλο. Ἀναγκαῖον δὲ καὶ τὸν καυλὸν καὶ τὸν περίνεον τῶν πραοτέρων ψυκτηρίων καταχρίειν τινί. ὀνίνησι γὰρ ἐγγύτερον, ὥστε, εἰ καὶ τῆς λιθαργύρου, καὶ γῆς τῆς κιμωλίας καὶ τῆς ἐρετριάδος, καὶ τοῦ ψιμυθίου καταχρίοις, πρὸς τοῖς εἰρημένοις καὶ ἕν καὶ δύο μίσγων, συμφέρει ἄν; Daremberg 1879.) Dioscorides recommended the earth of Samos, rich in borates, combined with milk for

Fig. 1. A variety of medicinal earths including Terrae Noceriana, Samia and Lemnia from the Royal Pharmaceutical Society Museum collection. Photograph by the author with permission.

Fig. 2. Close-up view of Terra Sigillata with inscription preserved. This troche, measuring approximately 18 mm in its maximum diameter, was found in 1931 in one of the Sloane pharmaceutical drawers (see also Retsas 2012). Its provenance is believed to be the Island of Lemnos. Copyright Natural History Museum, London. Photograph by the author.

the treatment of ulcerated and discharging eyes. (ποιεῖ πρὸς τὰ ἐν ὀφθαλμοῖς ῥεύματα καὶ ἕλκη σὺν γάλακτι; *in* Kühn 1829, I; p. 823.) He stated that the earth of Chios had similar properties. Until the mid-twentieth century boric acid (H_3BO_3) was used, usually with borax ($Na_2B_4O_7$), as a buffer in eye drops (Martindale 1982, p. 337). Boric acid possesses weak bacteriostatic and fungistatic properties, but has been superseded by more effective and less toxic disinfectants.

The Sloane earths

In addition to Lemnian earth, Sloane (Retsas 2012) also lists in his manuscript catalogues earths from the islands of Kimolos (cimolia) and Samos (Figs 1–3). For sore eyes, Sir Hans Sloane (1660–1753) introduces his own recipe. In his paper 'An account of a most efficacious medicine for sore eyes', dedicated to his sovereign, he writes:

> Sir, This account of my most *Effectual Medicine* for the cure of *Sore* and *Weak Eyes*, is now made public for the Benefit of Mankind; and most Humbly Dedicated to Your MAJESTY, by *Your* MAJESTY'S, *Most Dutiful*, and *Most Obedient, Subject and Servant,* HANS SLOANE (sic).

Fig. 1. A variety of medicinal earths including Terrae Noceriana, Samia and Lemnia from the Royal Pharmaceutical Society Museum collection. Photograph by the author with permission.

Fig. 2. Close-up view of Terra Sigillata with inscription preserved. This troche, measuring approximately 18 mm in its maximum diameter, was found in 1931 in one of the Sloane pharmaceutical drawers (see also Retsas 2012). Its provenance is believed to be the Island of Lemnos. Copyright Natural History Museum, London. Photograph by the author.

the treatment of ulcerated and discharging eyes. (ποιεῖ πρὸς τὰ ἐν ὀφθαλμοῖς ῥεύματα καὶ ἕλκη σὺν γάλακτι; *in* Kühn 1829, I; p. 823.) He stated that the earth of Chios had similar properties. Until the mid-twentieth century boric acid (H_3BO_3) was used, usually with borax ($Na_2B_4O_7$), as a buffer in eye drops (Martindale 1982, p. 337). Boric acid possesses weak bacteriostatic and fungistatic properties, but has been superseded by more effective and less toxic disinfectants.

The Sloane earths

In addition to Lemnian earth, Sloane (Retsas 2012) also lists in his manuscript catalogues earths from the islands of Kimolos (cimolia) and Samos (Figs 1–3). For sore eyes, Sir Hans Sloane (1660–1753) introduces his own recipe. In his paper 'An account of a most efficacious medicine for sore eyes', dedicated to his sovereign, he writes:

> Sir, This account of my most *Effectual Medicine* for the cure of *Sore* and *Weak Eyes*, is now made public for the Benefit of Mankind; and most Humbly Dedicated to Your MAJESTY, by *Your* MAJESTY'S, *Most Dutiful*, and *Most Obedient, Subject and Servant,* HANS SLOANE (sic).

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'Serpent stones': myth and medical application

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Abstract: 'Serpent stones' have been credited with medical efficacy since antiquity. Likely having their root in ancient traditions from India, accounts are now widespread across much of the world. Serpent stones are known by many names and descriptions of their appearance and medical uses are diverse; however, they commonly have a legendary association with serpents and are most frequently considered efficacious in the alexipharmic treatment of snakebite. This work presents and details five broad categories of serpent stone: a round white stone (thought to be extracted from the head of a dragon), a smooth lens-shaped black stone (purported to be taken from the head of a snake, but artificially manufactured of burnt bone or horn), ammonites (the fossilized shells of extinct cephalopods), glass or vitreous paste in the form of rings or beads, and serpentinite.

Serpent stones have been used in lapidary medicine since ancient times. Descriptions of their appearance and medical uses appear with surprising frequency in Medieval and Early Modern literature; accounts are known from Europe, India, the Far East, Africa and the Americas. Serpent stones have a high level of nomenclatural diversity and have been termed adderstones, *clach na thrach*, *milpreve*, *lapis ophites*, *lapis serpentinus*, *lapis serpentis*, *pierres de cobra*, *piedra negra*, the poison attracting stone, the Belgian Black Stone and the Black Stone, among others. Accounts contain significant variation with regard to the appearance, generation, means of harvesting, identity and therapeutic virtues of serpent stones. English palaeoanthropologist Kenneth Oakley (1911–81), writing on the use of fossils as charms, addressed this plethora of conflicting identifications, stating 'Many quite different objects passed for adderstones, particularly fossils and stones whose markings suggested an intertwining of snakes' (Oakley 1978, pp. 234–235); to this we can add stones which were thought to have been generated by snakes. Using these broad initial criteria, a survey of the literature on serpent stones enables categorization into five main types of stone. The first of these categories, for the moment, defies definite scientific identification but the other four are verifiable geological or artificial anthropogenic items. The accounts consulted do not demonstrate that authors were aware of different types; most were under the impression that the stone they commentated upon was the only variety of serpent stone. A few were aware of two types of stone, and Gaius Plinius Secundus (Pliny the Elder, AD 23–79) in his compendious work, *Historia Naturalis* (*Natural History*), referenced four of the five types in disparate sections within its pages, although attempts at comparison were not made. These categories are broad and some accounts do not fit comfortably into one or the other, but they do provide a starting point for classification using key characteristics and hence a starting point for further investigation into this rich area of study.

Early references from the East

The earliest reference to serpent stones identified so far is in the Assyrian medical texts from Ashurbanipal's library at Nineveh. These clay tablets, written in cuneiform and dating to around the seventh century BC, give tantalizingly brief information; the stone itself is not described but is listed among 20 other stones credited with being effective against the supernatural affliction of 'hand of ghost' when tied to the painful area (Scurlock 2006, No. 176). 'Hand of ghost' was shorthand for seizure by the hand of a ghost, either a departed relative or an unquiet spirit, then thought to be the cause of a range of physical ailments (Scurlock 2006, p. 10).

Early Indian serpent stones were gemstones that were said to form naturally within the head or neck of a serpent. The Indian collection of fables *The Panchatantra*, thought originally to be composed around 200 BC although many stories themselves may have predated this (Ryder 1925, p. 4), mentions that 'gems proceed from the hood of snakes' (Ryder 1925, p. 38). This work being a *niti-shastra*, or textbook for a wise life (Ryder 1925, p. 5), seeks through this example to encourage the reader, in modern parlance, 'not to judge a book by its cover'.

The *Garuda Purana*, which may date to as early as *c.* AD 400 (Stietencron *et al.* 1992, p. 871, Item 5003), specifies that pearls are produced in several animals, including snakes; the serpent pearl is called *Nagmani*. The stones are described as round in shape with a 'dazzling effulgence'; the possessor of the serpent stone is said to 'meet with a rare

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subjected to the violence of weather and waves and to corsairs and pirates: '*la mer ne faisait pas rêver: elle faisait trembler*' (the sea did not make people dream: she made them tremble) (Vergé-Franceschi 2002). But Sperling's friends among the Copenhagen doctors, and Dr Fincke in particular, warmly recommended the journey to Bergen that would probably offer, they said, great opportunities for seeing and studying Norway's plants and other particulars. Sperling accepted and he obtained quarters on board the ship *St Anna* 'down in the Artillery with Mr *Secretarius* Friedrich Günther' (Sperling [1673] 1885, p. 5).

In Bergen, Sperling was invited to stay with the local *medicus*, who enjoyed discussions with the student. Sperling noted 'He was a learned man and had travelled much both in Italy and France, but he was no *Botanicus* and not at all *curieux* on the matters of Nature' (Sperling [1673] 1885, p. 6). This absence of interest astonished the student, who himself went out and collected plants, studied animals, climbed rocks, one higher than the other and 'difficult to climb as there was no path to follow'. In the home of the *medicus* Sperling met Norway's Kansler Jens Bjelke (1580–1659; Rikskansler in Norway 1614–48; the Kansler in Norway was the King's representative attached to the Court of Justice). Kansler Bjelke was curious about nature and took such a great interest in Sperling that he invited him to join him after the Herredag, and some further business, on his travel back to his estate and to stay there for some time.

Leaving Bergen, they sailed among the skerries to Stavanger, where the Kansler had disputes to settle. This gave Sperling time to explore the environment. In his autobiography he recalled a plain with a large lake and at its shore fishermen who had caught 'some very large, black clams', which they opened, looking for pearls, of various colours and qualities. 'Among the irregular pearls I took some that I still keep among my rarities as well as some shells of the clams due to their extraordinary size'. The older Sperling added, 'I have since found much larger shells at several lovers of rarities'. From a boat in the harbour he observed growths on the sea bottom and among them '*Corallina*, both in red and in white colours, that is used by *medici* against worms and is normally procured by the pharmacies from foreign countries' (Sperling [1673] 1885, pp. 7–8) (*Corallina officinalis* is a calcareous red seaweed, often called common coral weed).

Having completed his duties in Stavanger, Mr Bjelke set out with Sperling cross-country, by boat over the fjord and on horseback over land, to his estate. On the way, they discussed theological matters and always in Latin, but in the Bjelke family Sperling 'began from necessity to learn Danish because nobody could speak German'. The elder daughter, Dorothe, in particular appreciated talking with him, he remarked. Sperling noticed good-humouredly that the Kansler, when at home, spent most of his workdays in bed, doing all his official and personal writing as well as composing psalms there and not getting up until 2 or 3 o'clock in the afternoon, when a meal was served, with another meal being served at midnight. While in Bergen, Mr Bjelke had purchased a small *clavecymbel* on which he could play only four pieces of music – and those only moderately well. Sperling could play the instrument and Mr Bjelke wanted him to teach Dorothe who, according to Sperling, had 'a very good *Ingenium*' for music. She learned quickly and delighted everybody.

The student took leave from the Bjelkes in the autumn of 1622 and travelled to see a relative in 'Opslo' (the old Oslo, until the great fire in 1624; rebuilt closer to Akershus Fortress and renamed Christiania; in 1924 renamed Oslo) and to look for a shipping opportunity to Copenhagen. While waiting, he called on the local bishop, who told him about a copper exposure at 'Fieringen 10 Mile away' (Feiring, at Lake Mjøsen, a good 85 km by road from Oslo). A passport was required and the bishop asked the Statholder (Governor General; Jens Juel (1580–1634) was Statholder in Norway from 1618 to 1629 and promoted mining) for one, which resulted in an invitation to Sperling to see animal paintings and talk about rarities, and also to join the Statholder for dinner. Thereafter, on his way to the exposure, he had to cross Mjøsen, which was said to be dangerous because, according to the peasants, it was bottomless and the devil lived there. Sperling did not let the warnings interfere with his curiosity and intention to see the site. He found it to be poor in copper, 'but the ore gives, when roasted, a very beautiful blue vitriol [copper sulphate]' (Sperling [1673] 1885, p. 11). A footnote by Birket Smith explains that in '1639 Christen Bang in Christiania obtained permission to run a mine there'. *Bergvesenet (rapport nr 2376)* in Trondheim (Geological Survey of Norway) reports that Feiring was given mining rights in 1537 and that copper mining is documented there from 1621 (the last company, A/S Feiring Kobberminer, was denied a concession in 1914, and most mines are now backfilled). Sperling does not indicate how he acquired this minero-chemical insight. Whether he learned it from local miners or undertook the analysis himself based on his medicine-related training in chemistry (perhaps supported by the German mining tradition?), the circumstance that he, half a century later and in prison, recalled the Feiring copper ore and the associated chemical reaction producing blue vitriol testifies to concern and to an analytical approach to Earth features. It is in harmony with his rejection of superstition.

Superstitions linked with landscape features and minerals existed then and still exist worldwide. In SW Greenland, in the Ikka Fjord, the spooky, whitish, columnar bodies rising from the fjord bottom and visible through the waters were held by the Inuit to be the Norsemen from a nearby farm who were attacked by Inuit hunters and fled onto the fjord ice, which then gave way (Brooks 2016). The lore explains the occurrence of the strange subaqueous bodies to the traditional Inuit. To scientists, the bodies are ikaïte, the mineral calcium carbonate hexahydrate, which only crystallizes in cold water and forms tufa chimneys and mounds in the Ikka (formerly Ika) Fjord (e.g. Pauly 1963; Johnsen 2002; Petersen & Johnsen 2005; Brooks 2016). The Norsemen were Scandinavians, 'whites', who came to SW Greenland via Iceland as settlers in the Viking Age and who later disappeared. The lore may contain the truth that the Inuit contributed to the extermination of the Norsemen in Greenland.

Encounters with fossils

In 1623 Sperling received a letter from Dr Fuiren, who invited him to take part in a botanical expedition to Scania, Halland, Blekinge and the Isle of Gotland, all of which were Danish provinces (now Swedish). Sperling noted in his autobiography that Dr Fuiren was a very rich man who did not feel happy with his medical practice, but was a capable botanist. As recorded by Herholdt (1811), Christian IV, because of the interest he showed in chemical and botanical studies, defrayed the expenses of the expedition. Sperling, who at that time was in Hamburg, travelled to Copenhagen and they set out on the first leg of the expedition. On their return, they embarked on a royal ship bound for Gotland to take in timber and tar for the shipworks at Holmen in Copenhagen. They arrived safely at Visby and travelled all over Gotland, finding many rare plants.

Sperling's autobiographical record of the botanical expedition was summarily reproduced by Birket Smith (1885), who informs us that they also visited some of the small islands close to Gotland, where they found beautiful petrifactions and, on one of the islands, Sperling discovered a runic inscription, which he copied. According to Sperling's manuscript, p. 53 (Fig. 2)

> Und ob wir zwar keine newe [neue] kräuter auff diesen eylanden funden, so fandt ich doch daselbst, viele schöhne petrificierte Sachen, und gantze klippen von Sternstein *Astroïtes* oder *Lapis stellaris* genandt, wovon Ich gueteprovision mitnahm [And although it is true we did not find any new plants on these small islands, I did find many beautiful petrified things, and whole rocks of starstones by the name of *Astroïtes* or *Lapis stellaris*, of which I took a good number with me].

The term 'petrificierte Sachen' indicates that Sperling acknowledged the process of petrification or mineralization in nature. By 'starstones', '*Astroïtes*' and '*Lapis stellaris*', he identified the objects on outer form without regard for animal or plant relationships (many names of organisms and objects are still purely pictorial, referring to superficial similarities rather than to true relationships; Linnaeus, a century after Sperling, systematized largely on the basis of form). 'Petrificierte Sachen' might be: (1) mineralized organic objects; (2) mineralized infillings, i.e. moulds, in voids after the dissolved parts of organisms embedded in geological deposits – a mould reproduces the external form of the organic object, but not its internal structure; or (3) minerals precipitated in certain limited geochemical environments unrestricted by organic forms, such as flint and pyrite nodules – these may have superficial resemblance to parts of organisms. In our modern understanding, (1) and (2) represent fossils, whereas (3) does not. Ole Worm was aware of this distinction (Hoch 2013) and so, presumably, was Sperling and therefore restricted his 'petrificierte Sachen' to objects we would now call fossils.

Palaeontologists and like-minded people in the centuries after Sperling's time, formally beginning with the studies of Georges Cuvier in the late eighteenth century, saw fossils as remains or traces of extinct organisms hardened by mineralization in the ground. To Sperling and his contemporaries, the extinction perspective was absent. Young Sperling had inevitably listened to discussions among the *medici* he knew in Copenhagen about the interpretation of stony objects that look very much like parts of organisms, saying that they may originally have been parts of organisms. Ole Worm was much engaged in such problematic questions and was eagerly making collections of *naturalia*, including fossils, and *artefacta* for a museum he used for hands-on teaching. Shells and wood at various stages of petrification were reported from the Isle of Sheppey in the mouth of the Thames by the Danish physician Christen Stougaard in a letter of 30 June 1627 to Ole Worm (English translation in Hoch 2013, p. 317) with associated sampled specimens. That wood may become naturally petrified was indisputable knowledge in the mid-seventeenth century, when the English philosopher Thomas Hobbes (1588–1679) stated in *Leviathan* (Hobbes (1651) 2006, p. 246)

> if a man be metamorphosed into a stone, or into a pillar, it is a Miracle; because strange: but if a peece [sic] of wood be so changed; because we see it often, it is no Miracle.

Conrad Gessner (1516–65), a physician in Basel, had written the first known book on fossils with illustrations, *De Rerum Fossilium, Lapidum et*

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The term 'petrificierte Sachen' indicates that Sperling acknowledged the process of petrification or mineralization in nature. By 'starstones', '*Astroïtes*' and '*Lapis stellaris*', he identified the objects on outer form without regard for animal or plant relationships (many names of organisms and objects are still purely pictorial, referring to superficial similarities rather than to true relationships; Linnaeus, a century after Sperling, systematized largely on the basis of form). 'Petrificierte Sachen' might be: (1) mineralized organic objects; (2) mineralized infillings, i.e. moulds, in voids after the dissolved parts of organisms embedded in geological deposits – a mould reproduces the external form of the organic object, but not its internal structure; or (3) minerals precipitated in certain limited geochemical environments unrestricted by organic forms, such as flint and pyrite nodules – these may have superficial resemblance to parts of organisms. In our modern understanding, (1) and (2) represent fossils, whereas (3) does not. Ole Worm was aware of this distinction (Hoch 2013) and so, presumably, was Sperling and therefore restricted his 'petrificierte Sachen' to objects we would now call fossils.

Palaeontologists and like-minded people in the centuries after Sperling's time, formally beginning with the studies of Georges Cuvier in the late eighteenth century, saw fossils as remains or traces of extinct organisms hardened by mineralization in the ground. To Sperling and his contemporaries, the extinction perspective was absent. Young Sperling had inevitably listened to discussions among the *medici* he knew in Copenhagen about the interpretation of stony objects that look very much like parts of organisms, saying that they may originally have been parts of organisms. Ole Worm was much engaged in such problematic questions and was eagerly making collections of *naturalia*, including fossils, and *artefacta* for a museum he used for hands-on teaching. Shells and wood at various stages of petrification were reported from the Isle of Sheppey in the mouth of the Thames by the Danish physician Christen Stougaard in a letter of 30 June 1627 to Ole Worm (English translation in Hoch 2013, p. 317) with associated sampled specimens. That wood may become naturally petrified was indisputable knowledge in the mid-seventeenth century, when the English philosopher Thomas Hobbes (1588–1679) stated in *Leviathan* (Hobbes (1651) 2006, p. 246)

> if a man be metamorphosed into a stone, or into a pillar, it is a Miracle; because strange: but if a peece [sic] of wood be so changed; because we see it often, it is no Miracle.

Conrad Gessner (1516–65), a physician in Basel, had written the first known book on fossils with illustrations, *De Rerum Fossilium, Lapidum et*

Gemmarum [etc.] (Gessner 1565). In cases of conspicuous similarity, Gessner would show the petrifactions together with similar parts of extant organisms, such as tonguestones together with shark teeth. One of the woodcuts in *De Rerum Fossilium* showed '*Asterias*' and 'Belemnitae' (Prothero 2003, fig. 1.2), with which Gessner could find nothing to compare. Sperling may have first learned about Gessner from his father when he was a boy; his father later donated him *Gesneri Opera de animalibus* (Sperling [1673] 1885, p. 42). Becoming more conversant with literature during his student years, he presumably also knew *De Rerum Fossilium*. He recognized the Gotland specimens he had collected as *Asterias*, starstones, *Astroïtes* or *Lapis stellaris,* but, like Gessner, he was unaware of their biological relationship.

Various shiny minerals may be called starstones by modern traders in precious stones (Afghan tradesman, pers. comm.). Among the seventeenth-century collectors of 'rarities' in Europe, starstones were stones that exhibited a conspicuous, simple, star-shaped (in the colloquial meaning) pattern or form. To palaeontologists, they are the fossilized skeletal parts of organisms with a radiate symmetry. Starstones were often the fossilized skeletal parts of the marine invertebrates crinoids or corals, both groups with long geological histories. The pattern of pentaradiate symmetry seen in crinoids also characterizes most other echinoderms, the five-armed starfish being iconic in this respect.

The starstones collected by Sperling were presumably the skeletal parts of crinoids (and perhaps other echinoderms, now extinct). There are rocks made of starstones on Gotland and the neighbouring small islands that consist almost exclusively of the skeletal parts of crinoids (and cystoids) from a rich fauna that lived between reefs on the bottom of a sea that once covered this part of the Baltic region. These Gotland (formerly Gothland) fossils are so well known in geology that earlier generations of French geologists named the time period in Earth history when these particular animals lived Gothlandien (Termier & Termier 1960). The name Gothlandien has since been substituted by Silurian (English) or Silurien (French) for the time period 444–416 Ma ago (Gradstein *et al.* 2004).

Sperling's mention of a runic inscription immediately after the petrifactions (Fig. 2), as well as his careful copying of it, may strike a reader in our time as a digression from his nature studies. However, whereas to modern Europeans runes and fossils are entirely different, the former made by humans and the latter products of nature, to many people in the seventeenth century the two were allied species. This was evident from the fact that both occurred as peculiar marks in stones and both were associated with occult powers. Sperling did not share such views. His interest in the runes he had discovered may be seen as another indication of the Copenhagen influence, especially that of Ole Worm, who was both a collector of petrifactions and a great runologist. Runes are the alphabet of the ancient Germanic-speaking peoples in the Viking Age and they were still used in Nordic official documents into the thirteenth century. The Christian religion promoted the Latin or Roman alphabet and general knowledge of runes died out in the fifteenth century (Kjems 2006). In the seventeenth century, runes and fossils might scare laypeople, but some Renaissance researchers recognized their potential to inform us about real events and processes from beyond trivial wisdom.

Medical studies resumed

After the botanical expedition, Sperling spent the winter in Hamburg. A relative from Nürnberg visited the Sperling family and it was decided that Otto should travel with him to Nürnberg in the early spring with the aim of studying medicine in Padova. On his way south from Nürnberg, he travelled on foot from Augsburg to Innsbruck and Bolzano, and then on a raft down the River Adige to Verona, reaching Padova in May 1624. The University of Padova attracted many students from northern Europe. Toftgaard (2016) mentions 355 students from Denmark and Norway studying in Padova between 1536 and 1660. It is noteworthy that in 1643 Christian IV raised the status of Sorø Akademi (80 km west of Copenhagen) to that of a university, and thus a school for advanced studies with foreign teachers, to allow Nordic students to learn without having to travel far in Europe.

In Padova, Sperling met with German students in the so-called German Nation and was grateful to have access to their library. After matriculation he began advanced studies in medicine, including studying plants in the associated botanical garden. As *studiosus medicinae* he was mainly attached to Professor Adrianus Spiegelius (Adriaan van den Spiegel, 1578–1625) and followed him in his practice. From that time, Sperling related that another respected physician, Dr Andergethus de Andergethiis (dates unknown), had treated a patient for dropsy for a long time without success when Sperling suggested that they rub the ill man with mercury ointment. In the 1600s this was the common cure for some venereal diseases. Dr Andergethiis accepted the idea and, although the patient first grew pitifully worse, he did eventually recover. While working on his autobiography, Sperling may, of course, have enjoyed recalling this instance of personal success from his student days. The story, however, has more profound significance. Sperling may have recognized and diagnosed the illness as syphilitic independently of the professor's diagnosis. What is particularly important here is that he recommended a treatment that had a tried experimental background, but was unconventional under the conditions present. In retrospect, it is evident that Sperling had a fine doctor's intuition and was open-minded and inventive when faced with problems.

Sperling spent three and a half years in the Italian lands where, for two periods, he followed a formal medical education in Padova. In 1625 he visited Venice in the spring and Istria in the summer to study plants. Later that year, he and a German student of medicine set out on a voyage that took them from Padova, Mantova and Bologna across the Apennines to Firenze (Florens), Pisa, Livorno, Roma and Napoli. Returning through Rome, Ancona and Rimini, Sperling sent a letter dated 2 November 1625 from Padova to his father telling him that he had taken up studies again, now focusing on anatomy and surgery. This lasted until his tutor, Professor Spiegelius, returning from a visit to Venice, brought news about a Venetian nobleman, Nic Contarini (undoubtedly Nicolò Contarini (1553–1631), 97th Doge of the Venetian Republic from 1630 to 1631), who asked Sperling to keep him company and look after his very fine garden and castle outside Venice. After some deliberation, Sperling accepted the proposal.

There is plenty of evidence in the autobiography that Sperling studied medicine with interest and intermittently with enthusiasm, so it was hardly displeasure with Sperling's efforts as a student that drove Spiegelius to recommend him for the full-time employment proposed by Contarini. Professor Spiegelius acknowledged Sperling's profound engagement in botany and he may have valued the student's wide-ranging studies of plants within their particular natural environments as well as his curiosity towards natural and cultural phenomena, as manifested in his journeys. It could hardly have escaped the tutor's attention that Sperling was good at socializing and was liked, and that he was well-behaved and trustworthy as well as broadly knowledgeable. He also saw that Sperling valued the freedom to move about, observe and investigate as much as the opportunity to subject himself to academic schooling. Sperling's pecuniary situation may have entered into Spiegelius' thoughts. Whereas many students in Padova were nobles from wealthy families, Sperling had a humbler background. The absence of a family fortune might limit his ability to pursue the studies he most cared for, namely those of natural science and, in particular, of plants in association with nature, so also of animals, rocks and soils. It may be recalled that two of the greatest early natural scientists of the seventeenth century, the English parson-scientist John Ray (1627–1705) (botany, zoology, Earth sciences) and the Danish medico-scientist Niels Stensen (Steno) (anatomy and Earth sciences) depended on patrons for their studies and living expenses during important productive periods of their lives. In return, they helped their patrons in various ways, including teaching their children and curating collections of rarities (e.g. Wagner 1986).

It is tempting to interpret Professor Spiegelius' step to establish contact between Sperling and Contarini and the commission as a kind of visionary act. Spiegelius would have comprehended the value of the proposal for Sperling and he may have recognized Sperling's potential as a modern natural scientist. Later in the seventeenth century, the attitude of Steno, as summarized in a thought-provoking paper by Jens Morten Hansen, was that 'Nature should be studied in nature, not explained by "ideas" without studies' (Hansen 2009, p. 11). An unprepared reader of Hansen's paper may be led to think that Steno discovered the importance to knowledge of studying nature in nature all by himself. However, Sperling, 36 years Steno's senior, was of the same opinion, as can be seen from his activities. Sperling and Steno were crops sprung from the same soil, each influenced in his youth by ideas rumbling in the comparatively strong medico-scientific environment in Copenhagen during the latter part of the Nordic Renaissance. It was Ole Worm, for example, who had asked Thorlak Skulason (1597–1656), Bishop of Hólar in Iceland, to go to the beach, make a drawing and collect parts of a stranded narwhal and have them sent to Copenhagen to contribute to the refutation of 'the errors and fabrications of the crowd' concerning the unicorn (letter from Worm of 9 May 1638, Schepelern 1967, p. 68). It was part of the Renaissance ideology.

The Contarini garden outside Venice

Sperling began work in the Contarini garden. His manners and efforts not only enhanced the growth and embellishment of the plants and plans already there, adding new and rare species, but also inspired warm friendships with the Contarini family. When, about a year later, Sperling received a letter from his father begging him to complete his medical education in Padova and thereafter return home, because his father feared he would not live long enough to see Otto again, Sperling's upcoming departure was seriously regretted. Both Mr and Mrs Contarini gave Sperling rich presents and insisted he promise to return to them after he had fulfilled his obligations.

In a person's life, it may happen that one event that may have seemed trivial at the time in retrospect stands out as particularly decisive. The letter from Sperling's father was an outcome of fatherly love recognized and diagnosed the illness as syphilitic independently of the professor's diagnosis. What is particularly important here is that he recommended a treatment that had a tried experimental background, but was unconventional under the conditions present. In retrospect, it is evident that Sperling had a fine doctor's intuition and was open-minded and inventive when faced with problems.

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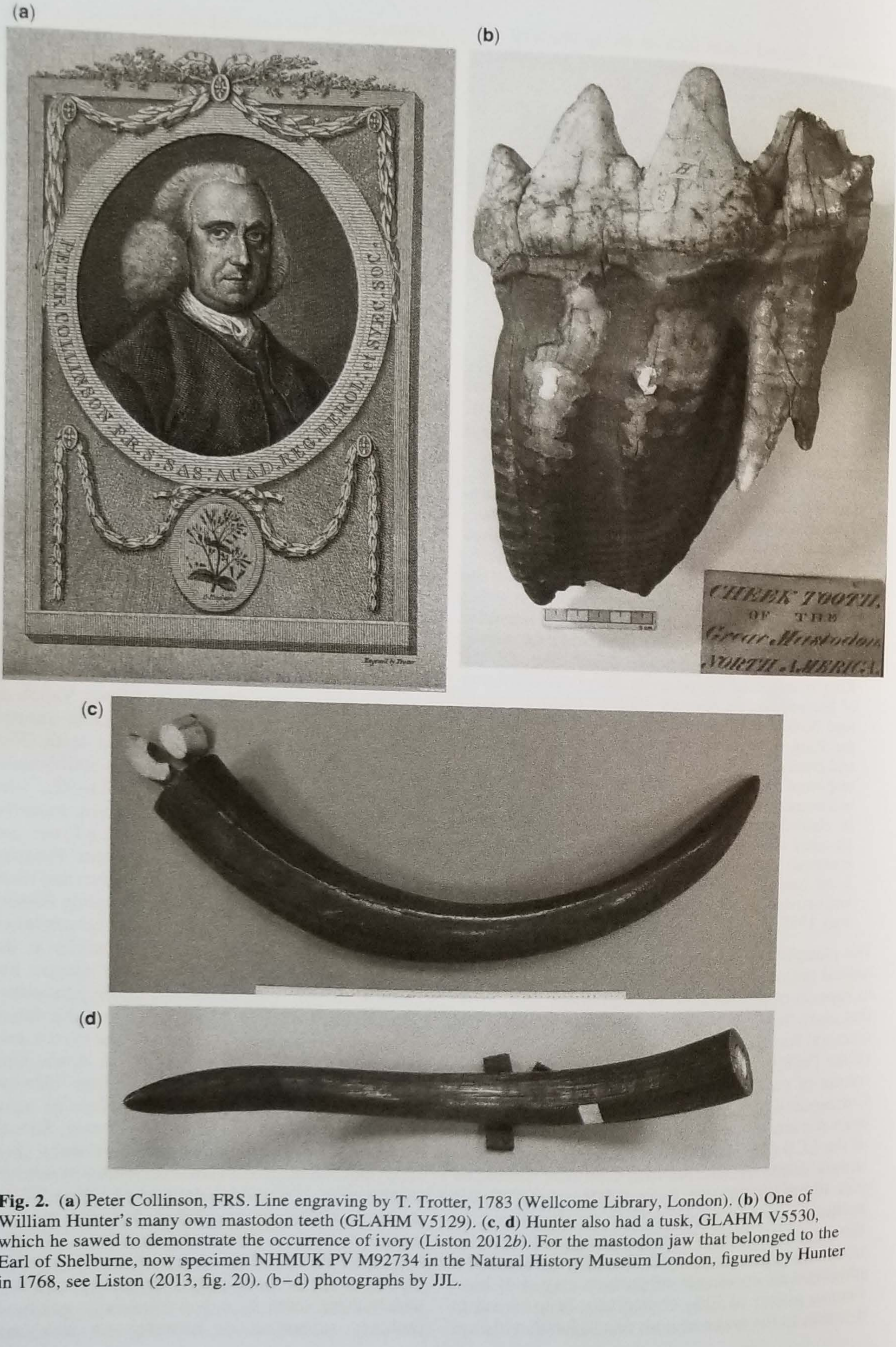

Fig. 2. (**a**) Peter Collinson, FRS. Line engraving by T. Trotter, 1783 (Wellcome Library, London). (**b**) One of William Hunter's many own mastodon teeth (GLAHM V5129). (**c, d**) Hunter also had a tusk, GLAHM V5530, which he sawed to demonstrate the occurrence of ivory (Liston 2012*b*). For the mastodon jaw that belonged to the Earl of Shelburne, now specimen NHMUK PV M92734 in the Natural History Museum London, figured by Hunter in 1768, see Liston (2013, fig. 20). (b–d) photographs by JJL.

shrubs, and other vegetable food' (Collinson & Croghan 1767, p. 469).

Collinson's presentation certainly seems to have made an impact on Hunter, who later noted 'This subject, tho a little out of the course of my studies raised my curiosity' (GB 0247 MS Hunter H135(5); see Liston 2012*a*). Using comparative anatomy, he was happy to declare at the Royal Society's meeting of 25 February 1768 that the 'Ohio incognitum' (later referred to as the mastodon) was not only very different from an elephant, but also that it had a distinctive diet:

> I shewed it to my brother [John] ... being particularly conversant with comparative anatomy, at the first sight he told me that the grinder was certainly not an elephant's. From the form of the knobs on the body of the grinder, and from the disposition of the enamel, which makes a crust on the outside of the tooth, as in a human grinder, he was convinced that the animal was either carnivorous, or of a mixed kind (Hunter 1768, pp. 36–37).

He also pointedly disagreed with Collinson on another point, as recorded by a clearly impressed Benjamin Franklin who was in the audience that night:

> ...he [Hunter] closed his paper almost casually, with an expression of thankfulness for a thought that must be called truly revolutionary: that this animal's 'whole generation is probably extinct'. The idea that any species ever become extinct was revolutionary at this time for it seems impossible to believe that an all-powerful and all-wise Creator (or, if one prefers 'the economy of Nature') would produce any species unable somehow to cope with its environment (Franklin 1970, p. 27).

Hunter wrote up his presentation for the Royal Society (Hunter 1768), contracting Jan van Rymsdyk to illustrate Lord Shelburne's mastodon jaw (now the Natural History Museum London specimen NHMUK PV M92734; see Liston 2013, fig. 20). This science was politically loaded, however, mixed with the potency of the national identity of an emerging nation across the Atlantic Ocean. As such, the mastodon was to play an unlikely role as a weapon in a transatlantic zoological war of words saturated with xenophobic prejudice between Georges-Louis Leclerc Comte de Buffon and another of America's future Founding Fathers and drafters of the Declaration of Independence, Thomas Jefferson (1743–1826).

From 1749 to 1809, Buffon produced 44 quarto volumes of *Histoire Naturelle* (Hunter possessed the 1749 edition; Liston 2013). As well as being an encyclopaedic book about the world's natural history, it was also a vehicle by which Buffon intended to convey his ideas about the New World. Despite having never visited it, he felt that the New World illustrated his Theory of Degeneration, whereby in a less favourable climate (as he declared the New World to be) the animals would be comparatively inferior in size compared to those of the Old World (Rolfe 1983*a*). In 1761 Buffon produced the ninth quarto volume, contrasting mammalian species that lived on both sides of the Atlantic Ocean, and claiming that the New World versions were always stunted and weaker. In order to rebut this, Jefferson produced the only book he ever wrote *Notes on the State of Virginia* (1785), in which he utilized two animals in particular to support his counterarguments. The first was the mastodon – which he genuinely believed still existed – arguing that it was 50% large than either living elephants or the Siberian mammoth; the second was the North American moose, under which he stated a European deer could walk. This latter group of animals (hoofed mammals called artiodactyls) would – in a similar way to the former elephantine relatives – also occupy William Hunter's attention within a palaeontological context.

Mastodons, Irish 'elks' and other dragons

Hunter was intrigued by the debate over whether the (sub)fossil remains of what was referred to as the Irish 'elk' (now known as *Megaloceros giganteus*) represented the same species as the then relatively unknown American moose (called 'orignal' in Canadian French) or European elk, or if it was a different animal altogether. If the latter then it appeared to be yet another extinct species; extinction was a prickly philosophical subject in the eighteenth century however, as shown by the responses to his description (Hunter 1768) of the 'incognitum' material, in particular from Pennant (1771, although see also review in Durant & Rolfe 1984). To ascertain if the Irish 'elk' was different, he first had to determine what defined living European and North American forms of such artiodactyls, and in so doing found the contemporary accounts sadly wanting. As Rolfe notes, elk specimens were unavailable in Britain in the eighteenth century until the Leverian Museum's specimen arrived in 1774 (Rolfe 1983*a*, note 42), so Hunter's only recourse was to sift the literature for descriptions of these animals, and assess the value of these accounts in the light of his anatomical experience to determine what an elk really was. In fighting his way through the morass of conflicting and contradictory accounts of European animals (as so ably demonstrated by the notes in Rolfe 1983*a*), Hunter was moved to write about previous commentators on the subject – in particular Buffon, whose thirteenth quarto volume (1764) had featured a bizarre figure purporting to be a 'European elk' (which might in fact be an alcelaphine antelope or a bovid; Grubb in Rolfe 1983*a*, note shrubs, and other vegetable food' (Collinson & Croghan 1767, p. 469).

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39): 'it is much to be questioned if the [preceding] Authors would have known an elk if they had seen one, and if they had gone to America it is much to be questioned whether they would have thought the orignal an elk' (Rolfe 1983*a*, p. 273).

Amidst this confusion over artiodactyl identification, one default position had held strong among those who criticized Hunter for stating that the 'Ohio incognitum' was extinct. Clearly (from their position of there being only an infallible Creator responsible for the living organisms populating the world), no animal could actually be 'extinct': ergo they simply had not yet been discovered alive, and in some as yet unexplored part of the world, they would eventually be found alive and well.

In this sense, these newly discovered animals were being placed into the same category as undiscovered animals in uncharted territories marked 'here be dragons' on ancient maps (e.g. the Latin form 'hic sunt dracones' on the sixteenth-century Lenox Globe; Ruitenberg 2007). Pennant (1771, p. 92) is typical in this regard when arguing against Hunter's declaration that the 'incognitum' was extinct:

> as yet the living animal has evaded our search; it is more than possible that it yet exists in some of those remote parts of the vast new continent, unpenetrated yet by Europeans. Providence maintains and continues every created species; and we have as much assurance that no race of animals will any more cease while the Earth remaineth, than seed time and harvest, cold and heat, summer and winter, day and night.

In short, it was the requirement of the prevailing beliefs of the time that these animals simply had to have survived in a distant and uncharted place yet to be fully explored, as the alternative was unthinkable. But by the end of the eighteenth century, such philosophers were rapidly running out of territories on the planet that might yet conceal such animals, and this presented Hunter with a novel means of resolving the question once and for all.

A two-pronged attack

After his experience with the 'incognitum', Hunter could anticipate what critics of extinction would say and so decided on a strategy to deal with them using the Irish 'elk' (Fig. 3a) – more properly referred to as the Irish deer – which he had specimens of in his museum (Fig. 3b, c). He wished to show that the remains of this animal represented an extinct species as he had demonstrated with the 'incognitum', but to do this he had to show that the living large artiodactyls in the wilds of North America did not represent a form with antlers (or 'horns') of the style of the Irish deer remains. To this end, Hunter commissioned George Stubbs to paint the Duke of Richmond's juvenile orignal (Fig. 4a; Liston 2010). This specimen was the first male orignal to have survived the journey to Britain and, judging from the palmation pattern and bull spike, it was only in its second year of life.

Also set within the foreground of Stubbs' composition was a full set of antlers from an adult specimen. Both the set of antlers, and the juvenile animal, were gifts to the Duke from General Guy Carleton, Governor General of Canada, later Lord Dorchester (Rolfe 1983*b*), who had brought both from Quebec. The purpose of this unusual addition was to show what the animal would grow to bear on its head.

In parallel, Hunter had unusually constructed a field questionnaire to be sent to North America to interrogate anyone who came across living large deer-like animals. As well as asking for confirmation that 'moose' and 'orignal' were simply local native American variations of the name for the same animal, the purpose of the questionnaire was to determine details of the growth of the antlers, and which of a series of antler styles they most resembled. This was an attempt to demonstrate that those who asserted that the elk or moose was the same animal as the Irish deer were not only wrong, but that the animal was not alive in the furthest recesses of North America and was simply extinct. It is evident that William Hunter was attempting to rule out the wilds of North America as a possible 'refugium' for Irish deer, and so put the matter of extinction well beyond doubt so that it might be seriously considered as a biological phenomenon. He must have known that it was possible that such animals might still live, as he was familiar with (and later came to own) Fothergill's collection with the second example of the 'living fossil' of the crinoid that attested to that (Durant & Rolfe 1984); instinctively, however, he must have felt that this was not the case, and wrote his conclusion regarding the Irish deer very much with that assumption in mind. The fact that he wrote in this way demonstrates how unfettered his mind was by having to comply with prevailing theological/philosophical beliefs. This was to be in some contrast to James Parkinson, several decades later.

It is clear that Hunter had not backed down at all from his published position on the mastodon: in contrast to Collinson's concluding assertion that it still existed, Hunter had pointedly concluded his description of the Ohio Incognitum with the words: '. . .though we may as philosophers regret it, as men we cannot but thank heaven that its whole generation is probably extinct' (Hunter 1768, p. 45). His manuscript for what would become known as *Megaloceros giganteus* echoed this original conclusion: 'The Irish Deer then was a noble animal of an *unknown* species, which like the American Elephant or *Incognitum* is still now probably extinct' (Rolfe 1983*a*, p. 276).

Hunter worked on the manuscript from 1770 to 1773 with the intention of submitting it for publication in the *Philosophical Transactions of the Royal Society* (Rolfe 1983*a*), having just published another palaeontologically related piece on a problematic specimen of bone breccia from Gibraltar (Boddington & Hunter 1770); ultimately, however, he did not submit the orignal manuscript. A variety of factors may have obstructed him, in spite of his conclusions already being in place. Firstly, this was approaching the time of maximum workload on the final plates of his obstetric masterpiece on the human *Gravid Uterus*, which had been almost 25 years in the making and only concluded in December 1774 (Liston 2013). Secondly, he may well have wished Stubbs to repeat his 1770 work on the juvenile for an adult orignal individual. This may have been problematic however: by July 1772 Hunter had shifted his focus to another male orignal which had passed from Lady North to Lord Orford, despite it being evidently younger than the individual he had examined two years earlier. He saw this individual again a year later in August 1773 and two months later examined another male orignal, this time fully two years old, presented to the Duke of Richmond by General Carleton, which Stubbs executed a pencil drawing of for Hunter (Rolfe 1983*b*; Fig. 4c). This suggests that Richmond's first orignal had died; otherwise he would surely have been able to visit, report on and get Stubbs to illustrate what would have been a more than four year old bull by that stage. Given that it takes these animals around five to seven years to reach sexual maturity, and perhaps fully eight years to equal the antler set in the foreground of Stubbs' painting that was full enough to be clearly not those of *Megaloceros*, it may be that none of these captive animals ever lived long enough to get to the point of possessing full enough antlers for Hunter's purpose. In this connection, a palmation sketch of an isolated orignal antler on the reverse of the title page of the auction pamphlet *A collection of pictures...collected by Robert Strange, which will be sold at auction... 7th of February 1771* (Hunterian Library Ek.1.1O.a), presumed to be by William Hunter (Fig. 4b), was noted by Rolfe (1983*a*, note 29) to be very similar to the left adult antler in the foreground of Stubbs' 1770 painting, but with two fewer tines. This indicates that he was building up a growth series for the antlers in his mind to interpolate between the juvenile bulls that he had seen and the isolated adult antlers.

The third factor that may well have inhibited the conclusion of Hunter's research is the outbreak of the US war of independence in February 1775. Not only is this event within two months of the first impressions of his *magnum opus* on the *Gravid Uterus* (Hunter 1774) being sent out (Liston 2013), and therefore remarkably close in time to the point at which that work was finally ceasing to have such a hold on his attention, but the Treaty of Paris that concluded those hostilities was not signed until September 1783, some six months after Hunter's death in March. The duration of this conflict would have had two significant impacts on the manuscript that Hunter was intent on publishing. Firstly, it would have no doubt impaired the efficiency with which Hunter's questionnaires could have been distributed and returned to him (indeed we have no proof that any of those questionnaires were sent out prior to the outbreak of hostilities); most likely he did not receive the data from North America that he required to complete his evidence-based argument that there was indeed only one type of moose-like animal in North America (and that its antlers did not during any growth stage resemble those of *Megaloceros*). Secondly, in view of the apparent mortality of the orignal specimens that had so far arrived in Britain, the conflict would also have hampered the shipping of any further replacement juvenile (or even adult) orignals to Britain, thus holding his desired conclusive image of the adult animal with its distinctive antlers perpetually out of reach. This was not the first time that war had been a barrier to Hunter's studies as, in a similar fashion, the War of the Austrian Succession (1740–48) twice delayed his trips to study anatomy in Paris (Liston 2013).

As a result, it was Cuvier who almost 40 years later gained the recognition for the piece of comparative anatomy that showed that the Irish deer was both distinct and extinct, based on a specimen from the Isle of Man (Fig. 3d), details of which were passed to him by Robert Jameson in Edinburgh (Cuvier 1823; Jameson also worked on the displays of William Hunter's fossil vertebrate material in the University of Glasgow, Liston 2015). The plaudits for Cuvier were however somewhat unwarranted, as William Hunter's friend Petrus Camper (1722–89) had actually already published the distinction between moose elk and Irish deer in 1788, only five years after Hunter's death. Rolfe posthumously published Hunter's manuscript in 1983 on the bicentenary of Hunter's death (Rolfe 1983*a*), making it one of the longest gestation periods undergone by a scientific manuscript before making it into academic print.

The orignal-Irish deer manuscript (Rolfe 1983*a*), the publication on the 'Ohio incognitum' (Hunter 1768) and a joint paper on a specimen of the Gibraltar bone breccia (Boddington & Hunter 1770) stand as William Hunter's three published palaeontological endeavours. However, having completed his obstetric masterpiece, Hunter had set his sights on or *Incognitum* is still now probably extinct' (Rolfe 1983*a*, p. 276).

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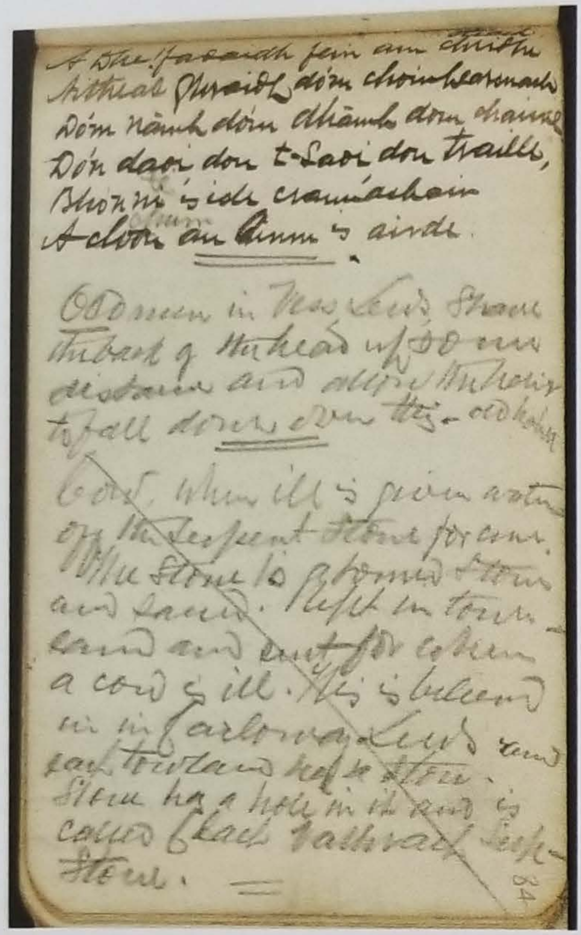

Fig. 5. Page from Alexander Carmichael's notebook, 1884. Coll-97/CW120/299, folio 84r. Note about the serpent stone. Copyright: University of Edinburgh, Special Collections.

In addition to treating snakebite, snakestone beads were also employed to remedy a variety of sicknesses in cattle. It was recorded as recently as 1905

> when cattle sickened it used to be the custom in the old days – and, indeed, until quite recently – to call in a man with 'charm stones' to conjure out the evil spirit (Lovett *et al.* 1905, p. 334–337).

Evil spirits were frequently thought to be the root of the trouble. Scotland was strongly influenced by the arrival of Christian missionaries from the late fourth century whose practitioners assumed the role of providing cures for both body and soul, and who propounded the view that disease was either a punishment for sin, or the work of evil spirits (Hamilton 1981, p. 4). The re-balancing of humours was also a consideration when treating illness but, if these methods were to fail, how else could a medieval mind, unaware of modern concepts of disease and contagion, explain the onset of mysterious symptoms? An invisible afflicter, be it an evil force, divine punishment or a higher heavenly purpose, therefore allowed for some form of justification (Porter 1987, pp. 24–27). Medical learning, which underwent significant development in the Early Modern period, was restricted to the upper orders of society. Although learned men could produce pamphlets and scathing denouncements of magical stones and similar remedies in academic works, the lower orders of society were unlikely to access these and maintained their traditional practices into the nineteenth century 'and it long remained acceptable to attribute certain forms of disease to the devil' (Porter 1987, pp. 26–27).

Further examination of the specifics of malevolent affliction reveals an account from Caithness which details that the snakestone bead was used to cure 'fairy darts' in sick oxen (Lovett *et al.* 1905, pp. 334–337). 'Fairy darts' are more commonly identified as elf-shot. While recent scholarship suggests that Anglo-Saxon elves were neutral beings who could assist or impede humans (Olsen 2007, p. 325), following Christianization of Scotland they were rather considered evil (Olsen 2007, p. 24–25). Scholarly use of the term 'elf-shot' has come under close scrutiny in recent years, and it has been asserted that 'scholarship touching on elf-shot is rife with confusion' (Hall 2005, p. 19); 'elf-shot' is sometimes taken to understand a disease attributed to the agency of elves, a projectile believed to be thrown by elves (commonly a flint arrowhead), a disease caused specifically by elves using projectiles, or even just witchcraft (Hall 2005, p. 19). However, Hall highlights that twentieth-century belief in elves characterized them as 'small, mischievous spirits who caused illness by shooting arrows (a phenomenon called "elf-shot")' (Hall 2007, p. 96). The illness was often identifiable as a sudden onset of pain, or even sudden death. Elf-shot tales are not restricted to Scotland, but are also found in Scandinavian countries such as Germany (where it is called *Hexenschuss*), Sweden (*skot*), Norway (*allskaadt*) and Denmark (*elleskud*) (Jamieson 1808, p. 68; Olsen 2007, p. 27).

In the Caithness example, the ritual to cure the afflicted animal was apparently witnessed by a curious neighbour who saw the practitioner

> rub the sick animal with the charm-stones, while at intervals he turned the stones over in the basket he had brought them in, saying 'Swate ye! Swate ye!' He then administered a 'drink of silver' (a bucket of water with a piece of silver money in it), and the animal was cured (Lovett *et al.* 1905, pp. 334–337).

Rubbing of the pained area – the finding of which was no mean feat, the wound allegedly being received beneath the skin with no external indication (various methods could be employed to first find the site; Davidson 1960, p. 283) – seemed to be considered the appropriate treatment of elf-shot. The rubbing was often performed with the item known as an elf-shot (or elf-arrow), a neolithic flint arrowhead (Davidson 1960, pp. 282–283), rather than a snakestone bead (Pennant 1790, p. 116; Brand 1813, pp. 336–339). However, Pennant notes that crystal gems and the snakestone bead were used interchangeably with the arrowhead, producing the same effect (Pennant 1790, p. 116).

Scottish social anthropologist Sir James George Frazer (1854–1941) adds that, in Scotland, the snakestone beads (in this instance identified as perforated glass beads) were considered a charm

> to repel evil spirits. When one of these priceless treasures was not on active service, the owner kept it in an iron box to guard it against fairies who, as is well known, cannot abide iron (Frazer 2002, p. 16).

Unusually, this suggests that perhaps the charm was not in itself immune to the depredations of fairy mischief.

In addition to snakebite and elf-shot, the snakestone bead was also employed in the treatment of livestock suffering other ailments. The Denham Tracts – a collection of 54 tracts on various aspects of folklore, collected between 1846 and 1859 by Yorkshireman Michael Aislabie Denham – relates a cure whereby the stone was 'placed over the backs of cows or other beasts as an efficacious remedy and preventive of the malady called hoose or huse; that is, difficulty of breathing' (Hardy 1895, p. 43). Hoose, more commonly called lungworm, is a respiratory disease caused by the nematode *Dictyocaulus viviparus*. This parasite is a worm which grows in the trachea and bronchi of infected cattle. The worm's eggs hatch within the host, before being passed into the faeces (Divers & Peek 2008, p. 109). Thereafter the larvae are dispersed up to 3 m away through the air by the sporangia of the *Pilobolus* fungus which grows on herbivore dung (Gaugler & Bilgrami 2004, p. 281; Elsheikha & Ahmed Khan 2011, p. 66). The larvae are passed to new hosts when contaminated grass is ingested (Divers & Peek 2008, p. 109). The parasite causes bronchitis and pneumonia in calves; early symptoms include rapid breathing, weight loss and reduced milk production, followed by a persistent cough (Blowey & Weaver 2011, p. 90). If the infection is severe, the animal may die from respiratory failure in the early stages of the disease or, if untreated, death may result from a subsequent lesion on the lungs or pneumonia (Taylor *et al.* 2016, p. 380). If left untreated, a proportion of victims will survive and recover. Adult cattle may develop a level of immunity to the parasite, but this will not necessarily be complete or able to withstand a strong infection (Divers & Peek 2008, p. 109); calves with little to no immunity are therefore most at risk from the parasite. Modern-day treatment is usually rendered by an anthelmintic course for affected cattle and, where possible, a prophylactic vaccine (Blowey & Weaver 2011, p. 90).

Although cattle were the animal most commonly treated by snakestone beads, horses were also cared for in this way. Northumberland folklore holds that 'holed stones, are hung over the heads of horses as a charm against diseases; such as that sweat in their stalls and are supposed to be cured by the application' (Balfour 1904, pp. 51–52). This account, however, is very suggestive of the use of a hag-stone. Hag-stones were employed to prevent a horse being stolen by a witch in the night and hagridden, causing it to appear 'highly distressed and foaming with sweat' in the morning (Duffin 2009, p. 61). The use of the snakestone bead to protect against affliction by witches is discussed in 'Witchcraft' below.

Other medicinal uses

Frazer comments that in Wales, the stones were thought to be 'particularly efficacious for all maladies of the eyes' (Frazer 2002, p. 16). As we have seen, Ure reports that they were worn as an amulet in cases of 'sore eyes' (Ure 1793, pp. 129–131). In Cornish and Welsh folklore, the snakestone is also known as the *maen magl*. '*Maen*' is Welsh for stone and '*magl*' can be interpreted as a knot or mesh; however, it also means the complaint of a 'web in the eye' (Pughe 1832, p. 320). This web can grow to cover the eye and was described as 'thin and white, sometimes thicker and more fleshy, rough, obscure and painful; nay, sometimes it becomes cancerous, which is incurable' (Croker *et al.* 1766, 'Unguis, Unguis Pannus'). This is commonly known as *Pterygium*.

In 1909, it was recorded that the snakestone bead was

> especially good for all affections of the eye. The owner of the bead states that for inflammation of the eyes, ulceration of the eyelids, and for sties, it is a never-failing cure if held or rubbed upon the affected part (Trevelyan 1909, p. 171).

Recently retired Welsh politician Rhodri Morgan (born 1939) recalls a tape recording of his grandmother in 1936 in which she mentions the snakestone, termed a *Mamacal* in the Llansamet dialect, and the method of its use in treatment of eye ailments:

> It could either be applied direct on the eye or more usually used to form a potion by pouring boiling water over the stone and waiting for the water to cool to a temperature when it could be used as an eye lotion (Brown & McNeil 2009, p. 188).

St Fagans Natural History Museum in Wales houses five adder-stones; the record cards for two of the five holdings indicate that the bead was 'used for healing known as an elf-shot (or elf-arrow), a neolithic flint arrowhead (Davidson 1960, pp. 282–283), rather than a snakestone bead (Pennant 1790, p. 116; Brand 1813, pp. 336–339). However, Pennant notes that crystal gems and the snakestone bead were used interchangeably with the arrowhead, producing the same effect (Pennant 1790, p. 116).

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‘Fish’, fossil and fake: medicinal unicorn horn

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Abstract: Ctesias (fifth century BC) recounted contemporary Persian beliefs of white Indian animals which had a white horn, black in the centre and flaming red at the pointed tip, projecting from their forehead. Reinforced by classical and medieval writers, travellers, biblical warrant and trade in narwhal tusk, the unicorn became firmly established in European mythology. Increasing popularity as an alexipharmic, prophylactic and counter-poison through the fifteenth to seventeenth centuries led to rising demand and rapidly inflating prices. Debate raged as to which was the ‘true unicorn’ (*Unicornum Verum*), narwhal tusks or mammoth ivory (*Unicornu Fossile*); shavings and powders of both were incorporated into a bewildering array of medicinal mixtures while fraudulent alternatives flooding the markets required the employment of discriminatory tests. Further alternatives with supposedly similar properties included the (probably smectite) clays of *Terra Sigillata Strigoniensis* or *Terra Silesiaca* (*Unicornu Minerale*), and an alchemical preparation (*Unicornu Solare*). The supposed therapeutic application and wide range of delivery systems of all types of unicorn horn medicines are reviewed in detail for the first time. Particularly popular as an antidote in plague medicines, the use of alicorn (unicorn horn) simples declined to extinction with the increasingly empirical approach to pharmacy of the mid-eighteenth century.

Although several publications have touched on the medicinal use of unicorn horn (Robertson 1926; Humphreys 1951; Boullet 1959; Miller 1960; Savare 1972; Fotheringham 2000; Jackson 2004; Gerritsen 2007; Fischer & Fischer 2011), there has so far been no deeper consideration of its therapeutic application during early modern times. The objective of the present paper is to consider the range of applications and means of delivery of the various materials promoted as unicorn horn in the history of pharmacy.

The unicorn and its horn, often referred to as an alicorn, have an iconic association with the apothecarial tradition. English apothecaries were originally associated in the same guild with the Grocers and Pepperers. Then, in 1617, James I of England established the Society of Apothecaries by Royal Charter. An application for armorial bearings was subsequently made to the Heraldic College later in the same year (Dickinson 1929). William Camden (1551–1623), the Elizabethan chronicler and topographer, was then in post as Clarenceux King of Arms, the senior of two Kings of Arms responsible for armorial matters and heraldic records. Camden devised a coat of arms that comprised two unicorn supporters flanking a shield within which Apollo, ‘the inventor of physique’, stood astride a prostrate dragon, representing disease. The crest is an image of a rhinoceros (Fig. 1). It is interesting to note that a short spiral horn has been drawn between the shoulder blades of the rhinoceros, following an earlier image by Albrecht Dürer (1471–1528; Fig. 2). The rhinoceros made its first appearance since antiquity in Europe in 1515. It was a gift for King Manuel I of Lisbon, from the Gujarat Sultan Muzafar II and landed after a rapid 120-day journey on 20 May 1515. Having been examined by scholars, the animal was then kept in the royal menagerie. A letter of unknown authorship was sent from Lisbon to Nuremberg at around the same time, enclosing a sketch by an unknown artist. Dürer – who was acquainted with the Portuguese community of the trading post (‘factory’) at Antwerp – saw the letter. Without ever seeing the rhinoceros himself, Dürer executed two pen and ink drawings, from the second of which a woodcut was then produced (Clarke 1986). Since the horn of the Indian rhinoceros did not accord with the spiral specimens then accepted as belonging to the unicorn, Dürer reconstructed a short additional anteriorly directed horn embedded in the tissues of the dorsal midline of the animal, between the shoulders. This error was then propagated through innumerable published and painted derivative images (Cole 1953).

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'Fish', fossil and fake: medicinal unicorn horn

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Abstract: Ctesias (fifth century BC) recounted contemporary Persian beliefs of white Indian animals which had a white horn, black in the centre and flaming red at the pointed tip, projecting from their forehead. Reinforced by classical and medieval writers, travellers, biblical warrant and trade in narwhal tusk, the unicorn became firmly established in European mythology. Increasing popularity as an alexipharmic, prophylactic and counter-poison through the fifteenth to seventeenth centuries led to rising demand and rapidly inflating prices. Debate raged as to which was the 'true unicorn' (*Unicornum Verum*), narwhal tusks or mammoth ivory (*Unicornu Fossile*); shavings and powders of both were incorporated into a bewildering array of medicinal mixtures while fraudulent alternatives flooding the markets required the employment of discriminatory tests. Further alternatives with supposedly similar properties included the (probably smectite) clays of *Terra Sigillata Strigoniensis* or *Terra Silesiaca* (*Unicornu Minerale*), and an alchemical preparation (*Unicornu Solare*). The supposed therapeutic application and wide range of delivery systems of all types of unicorn horn medicines are reviewed in detail for the first time. Particularly popular as an antidote in plague medicines, the use of alicorn (unicorn horn) simples declined to extinction with the increasingly empirical approach to pharmacy of the mid-eighteenth century.

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been discovered at Epsom, south of London, a few years before 1629 (Exwood 2000), where they were known to contain a bitter purging salt known as *Sal Catharticum Amarum*. To gain most benefit from them it was considered that they should be drunk at source, as they became putrid and undrinkable if transported. Attempts were made to obtain dry salts by evaporation and a physician Dr Nehemiah Grew (1641–1712) gave papers on the subject to the Royal Society as early as 1679, although these were never published. He served as the Royal Society's Secretary from 1677 to 1679 and edited their Philosophical Transactions from 1678 to 1679, probably giving him little time to write up his experimental work. Sixteen years later Grew published a treatise, in Latin, on these salts outlining their properties (Grew 1695). He set up a plant at a well in Acton where similar water to that at Epsom was found, selling the product. However, he quickly encountered competition from an apothecary Francis Moult (d. 1733) and his brother George (*c.* 1659–1727), sons of a city grocer, who supplied medicines to the West Indian Fleet, among others. At first they bought Epsom salts from Grew but then investigated other sources around London, deciding on the waters of Shooter's Hill from which they extracted a much greater quantity of salts than Grew could obtain at Acton. According to Brown (1723), in around 1700 they sometimes boiled down 200 barrels a week. In a dry season, when the spring water was not diluted by surface waters, this yielded 224 pounds (102 kg) of salt, enabling them to undercut Grew in price. To compound the dispute, Francis Moult had Grew's 1695 paper translated into English, without his knowledge, and gave copies away. Grew promptly made his own translation (Grew 1697), and obtained a Royal patent for making the salt and testimonials from eminent members of the Royal Society. He subsequently attempted to come to a legal agreement with the Moults who promptly took advantage of the situation, claiming they were now making the Epsom salts by Dr Grew's direction. The dispute never came to court and can be seen as part of a long-standing struggle between physicians and apothecaries over the dispensing of medicines (Sakala 1984). How long the Moults used the water is not known, but it is unlikely to have extended very far into the eighteenth century as a method was soon devised to obtain Epsom salts from the residue left following the crystallization of common salt from seawater (Brown 1723).

Mention of the Shooter's Hill water is made in Benjamin Allen's *Natural History of the Mineral Waters of Great Britain*, published in 1711 (Allen 1711). Described as clear with a very bitter taste, the water precipitated thin flakes at the bottom of bottles after a few days. However, the water is not described in treatises which appeared later in the eighteenth century (e.g. Rutty 1757; Russell 1760; Monroe 1770). Early topographic accounts (e.g. Hasted 1778; Hughson 1808) mention a mineral spring but only by referring to the broadsheet printed by Godbid; it seems unlikely that the waters ever became popular with London's citizens. One of the reasons for this is likely to have been its proximity 'to the great road which leads to Gravesend' mentioned as a convenience in the broadsheet. This road was steep and narrow, was bounded closely by woods and coppices and was infamous as the haunt of highwaymen and footpads. Celia Fiennes (1662–1741) noted that it was 'esteemed as a noted Robbing place' (Morris 1947, p. 132), and it was not until 1739 that improvements to the road were made.

Changes occurred to the west of Shooter's Hill at the beginning of the nineteenth century when, in 1806, the Royal Military Academy moved from a converted workshop at the Woolwich Arsenal to new buildings on Woolwich Common (Guggisberg 1900). The site of the purging wells seems to have been included within the estate of the Military Academy and subsequent descriptions refer to 'the mineral well', implying that only one of the original wells was still extant. According to Vincent (1888/90) the well was on the eastern edge of waste ground behind the Academy where, until about 1870, it was in the garden of a cottage. The location is confirmed by the 1866 Ordnance Survey London Sheet 107 (Fig. 1a) which shows the cottage to the rear of The Eagle Public House (subsequently The Eagle Tavern, Fig. 3), close to the junction of Red Lion Lane and Constitution Hill (subsequently Constitution Rise). The well appears to be in a small building or shed with a footpath leading to it from the cottage. The latter was occupied by a sapper, who had charge of the well on behalf of the Government, and dispensed water to visitors for a small fee. In 1884 Edward Walford records that 'The well is still visited by invalids of the neighbourhood' (Walford 1884, 2, p. 33). By 1888 the shed had disappeared and the well was covered by a flat stone (Vincent 1888/90), a situation confirmed by the 1894 edition of the Ordnance Survey Map (Fig. 1b).

The next edition of the Ordnance Survey map, published in 1914, no longer shows a well although the cottage and garden are still there. According to Bagnold, writing around 1937, the cottage and garden (which were then the property of the War Department) had been demolished about 13 years previously (i.e. about 1924; Bagnold 1936/38). Visiting the site, Bagnold felt that, although there was no longer any trace of the well, it had been located to the rear of number 80 Red Lion Lane. Some properties have since been demolished and the alignment of gardens has changed such that

Fig. 3. View down Constitution Rise to the Eagle Tavern with the Thames Flood Plain beyond. Photograph J. D. Mather, 2014.

the well was probably in the strip of ground behind what is now 90 Red Lion Lane. The Eagle Tavern closed in 2013 and, following an appeal, permission was granted for its conversion into five residential flats. The Royal Military Academy closed in 1939 but remained a Government site until 2006, when it was sold and the existing buildings converted and extended for residential use. The area would now be unrecognizable to the water drinkers who patronized the purging wells in the seventeenth, eighteenth and nineteenth centuries.

There are other springs and wells mentioned in historical accounts which rise from Shooter's Hill and which are sometimes confused with the Purging Wells. According to Vincent (1888/90) the hill was known to be 'full of water' and springs were abundant. A well on the top of the hill was said to constantly overflow and not to freeze, even in the sharpest weather (Hughson 1808). In 1769, a scheme was proposed to build a new town on the hill in which people were invited to invest. The centrepiece of this took advantage of the local springs to feed a lake with a circular island on which a coffee house was to be erected (Vincent 1888/90). The following century, local papers reported that Severndroog Castle, close to the summit of the hill, was about to be converted into a spacious hotel and gardens with spa-rooms for the convenience of taking the mineral waters (*West Kent Guardian*, 18 April 1835). It is not clear whether the mineral waters were to be brought from the source behind the Eagle Tavern or derived from elsewhere. In any case, both projects were abandoned. The only relicts of the once-abundant springs are street names such as Springwater Close and Brookhill Road and a canopy by the roadside, close to Christ Church, erected in memory of Samuel Edmund Phillips (1848–93), which once sheltered a drinking fountain but now only a seat remains (Fig. 4).

Hydrogeology

The geology of Shooter's Hill and the surrounding area was first surveyed at the 1:63 360 scale by William Whitaker and published in 1868 as part of Old Series Sheet 1. It was resurveyed at the 1:10 560 scale by C. E. N. Bromehead and published in 1924 at 1:63 360 scale as part of New Series Sheet 271 (Dartford), accompanied by a memoir (Dewey *et al.* 1924). Boundaries on the current map at 1:50 000 scale (BGS 1998) largely follow those of Bromehead, and a memoir (Ellison 2004) reviews current knowledge of the area within the broader framework of the London region.

The lower slopes of Shooter's Hill are underlain by the London Clay Formation of Eocene age (Fig. 5). This is a stiff grey to blue-grey fissured, silty clay, often thoroughly bioturbated, so that there is a uniform lithology throughout. At outcrop it is oxidized to a brown colour which is generally 3–6 m in thickness. The top few metres of unweathered clay and the bottom part of the weathered profile contain selenite (gypsum) as crystals up to several centimetres in length. Pyrite is also common throughout, as are carbonate concretions of varying size (Ellison 2004). The upper part of the London

Coral in Petrus Hispanus' 'Treasury of the Poor'

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Abstract: Coral features among the *naturalia* in the Cabinets of Curiosities in which, from the sixteenth century onwards, nobles and wealthy people exhibited their exotic riches and jewels. Petrus Hispanus (*c.* 1215–77), consecrated Pope John XXI, was also a doctor. This paper surveys the importance of coral as an amulet and a medicine in Petrus Hispanus' work within the folklore and the medical traditions of the time and in the framework of ancient lithotherapy, bringing the therapeutic use of coral into relationship with its chemical compound calcium carbonate.

The coral stone

Corals are skeletons secreted by small marine cnidarian animals, known as polyps. Corals in white, rose, red and blue are composed of calcium carbonate. Red and rose corals from the Mediterranean Sea have been popular since antiquity and commercialized in Europe, India and Arabia (Woodward & Hardins 1992). Black corals, described as arboreal, possessing a branching morphology, were called *antipathies* by Pedanius Dioscorides (*c.* 40–90), a Greek physician and one of the most celebrated pharmacologists and botanists of antiquity (García Valdés 2002, p. 334). These rare deepwater corals form a group of about 150 species called *antipatharians*. They were used as amulets and medicines in ancient times. Their main component is chitin and protein, usually with high histidine content (Goldberg *et al.* 1994, pp. 633–643) (Fig. 1).

Red coral, *Corallium rubrum*, was very valuable. In Greek mythology, coral was seen as the petrified blood of Medusa, killed by Perseus, falling into the sea. The legend of this most wonderful stone is recounted in the Orphic Lapidary (*Orphei Lithica*), one of the Greek Lapidaries, *Orphei Lithica Kerygmata*. The other Greek lapidaries are the *Lapidaries of Orpheus, Socrates and Denys* the *Nautical Lapidary* and the Latin translation of a Greek lapidary, *Damigéron Evax*. They are thought to have been written before the second century BC but our knowledge of these works is based on fourteenth-century manuscripts. They present coral both as an apotropaic device and as a medicine. The *Orphei Lithica Kerigmata* summarizes the alleged virtues of coral. It was considered in magic to help to carry out challenging tasks, in hunting, as a strong protective against all kinds of dangers and was thought to help ward off dangers in seafaring. Coral was also endowed with other divine virtues; when kept at home, it would drive away the evil spirits, ghosts and lightning. As a medicine, it would protect from poisons. Supposedly, when dissolved in pure wine coral was very effective against scorpions and snakebites (Halleux & Schamp 1985, pp. 109–114). When dissolved in water and drunk, it would soften the hardness of the spleen and help to prevent the bloody vomit (Halleux & Schamp 1985, pp. 160–161).

Fossil corals range from the Cambrian to Recent. Fossil coral may have been identified in the *Damigeron-Evax* lapidary, according to three Spanish palaeontologists (Liñán *et al.* 2013, p. 46) who reviewed the fossil samples in ancient lapidaries; they considered that the coral described in this lapidary and in the *Nautic* and *Damigeron-Evax* lapidaries may embrace both recent and fossil corals. (Fig. 2)

In his work *De Materia Medica*, the precursor of modern pharmaceutical texts, Pedanius Dioscorides (*c.* 40–90) dedicated chapter 74 and all subsequent chapters of book V to the description of the properties of metals, minerals and precious stones and their medicinal use (García Valdés 2002, pp. 288–351). Dioscorides (V, 121) described the coral as *lithodendros* (tree of stone), looking like a marine plant which hardens when it emerges from the deep sea and comes into contact with air. He praised the red coral which he said resembled *sandyx,* a Syrian pigment. Coral was described as a fragile homogeneous substance, similar to moss and seaweed. Dioscorides cited its medicinal uses as helping to remove excrescences, softening eye scars and filling tooth cavities. Supposedly it was effective in the treatment of blood-stained sputum and helpful in the treatment of urinary disturbances. When drunk in water, it was believed to reduce the enlargement of the spleen (Fig. 3). Dioscorides (V, 122) described the black coral as possessing the same healing properties (García Valdés 2002, pp. 333–334) (Fig. 4).

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Coral in Petrus Hispanus' 'Treasury of the Poor'

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