# Geology and Paleontology of the Lee Creek Mine, North Carolina, III

## Prodromus

*Clayton E. Ray*

Prodromus . . . a preliminary publication or introductory work.
WEBSTER'S THIRD NEW
INTERNATIONAL DICTIONARY, 1964

The archaic title is intended to reflect the antiquarian nature of this paper and to emphasize my conviction that our work on the Lee Creek Mine project, a quarter century of effort by many people, is decidedly preliminary. Publication began with volume I (Ray, 1983), which included papers on Remington Kellogg (to whom the series is dedicated), on the Lee Creek phosphate mine itself, and on stratigraphy and correlation, plants, and microfossils. The only paper specifically devoted to vertebrate fossils was that on otoliths of bony fish, included therein as "microfossils." That was primarily an unsuccessful effort to see the paper in print before the death of its senior author, John Fitch, who was then terminally ill. Volume II (Ray, 1987) was devoted exclusively to mollusks, the most conspicuously abundant and well-preserved fossils in the mine. Initially, it was planned that all vertebrate fossils, other than otoliths, would be included in a third, concluding volume (Ray, 1983:3); however, subsequent productive collecting, especially that by able and devoted amateurs, has resulted in great accumulation of more and better fossils. These have been subjected to thorough research by the contributors and, combined, expand the vertebrate papers beyond the reasonable confines of a single volume. The papers divide themselves conveniently into two sets, all groups other than mammals in this, volume III, to be followed by mammals, volume IV, which will include a taxonomic index to the publications of Remington Kellogg, predominantly on mammals.

This prefatory note continues the historical theme of those introducing volumes I and II, in which I attempted to review the early history of paleontological discovery and publication on the middle Atlantic Coastal Plain of British America. Having flattered myself that I had unearthed essentially everything, it is salutary to be reminded through several oversights that in antiquarian, as in paleontological, research one can never do too much digging. Returns in each are apt to be unpredictable and to be meager in relation to time invested (hardly "cost effective"), but there will always be something new, and, to comprehend it when found, one must be steeped in the subject. Thus, my primary objective is to rescue from obscurity or oblivion the additional early history that I have learned; not only to give credit to the pioneers, but to add to the foundation that may enable and inspire others to find out more, especially about American fossils surviving in European collections, and to dig further into the early literature. Thus, the present paper is an extension of those introducing volumes I and II and should be used in conjunction with them, as I have tried to avoid undue repetition of text and literature cited.

Although a full explication is beyond my scope herein and beyond my competence anywhere, I hope in reviewing these records to give some inkling of their importance, not only in the development of paleontology, but also in the broader intellectual concerns of the times. Fossils were more prominent in general scholarly discussions of the seventeenth and eighteenth centuries than at any time since. Although debate as to their na-

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ture and significance has long since dropped from the forefront of general investigation, we have by no means won the day. In western culture many educated people, including scientists, either ignore fossils or reject them as evidence of organic evolution, and humankind as a whole knows nothing of fossils (McIver, 1992; Lemonick, 1996).

No paleontologist can claim to be literate without thorough attention, not merely a perfunctory bow, to the role of fossils in western thought. Neglect of history is inexcusable in a historical science such as paleontology, but its literature in English is very skimpy, and that written by practicing paleontologists is generally narrow and shallow (although not universally so; e.g., see Ward, 1990), much devoted to "correcting" past mistakes and concepts in the light of present knowledge and fads. Of course we are obligated to correct objective errors in striving to approach truth ever more closely, but this is less and less specifically useful as we delve deeper into the ontogeny of our science. Much more satisfying is to understand the thoughts on fossils in the context and constraints of the times and the relevance of those thoughts to subsequent developments. The best primers on this subject in English are Rudwick (1976), especially the first 100 pages, and Drake (1996), the latter focused on Robert Hooke but with uncommon explication of context. Also very instructive are Challinor (1953), Morello (1979, 1981), and Young (1992). Davidson (2000:333) outlined the otherwise neglected role of Richard Verstegan in the early seventeenth century; however, she is mistaken in attributing the first published illustration, in 1605, of a shark's tooth to him. That distinction almost certainly belongs to Gesner (see Rudwick, 1976:30, fig. 1.9), who in 1558 even included a modern comparative specimen alongside his fossil. Davidson (2000:343) cited Gesner's work as probably available to Verstegan but mentioned neither Gesner's figure nor the work of Kentmann of 1565 in Gesner (see Rudwick, 1976:11–17).

These and other sources cited herein provide essential background on the principal players in the founding of paleontology, including, among others, da Vinci, Colonna, Scilla, Steno, and Hooke, and those in the interrelated development of collections, including Aldrovandi, Cospi, Giganti, Kircher, Mercati, Worm, and others. I refer to their work and its broader implications only in the course of resurrecting the primary reports on American fossils. These allusions should be sufficient to show that these reports are not mere curiosities of antiquarian delight but were integral to cutting-edge (see Maienschein, 1994, regarding this trendy term) intellectual concerns.

Although there is no universal agreement as to what or when the Renaissance was, few would disagree that it was earlier, stronger, wider, and deeper in Italy than it was anywhere else. It is no accident that Italian names, notably those mentioned above, dominate the earliest stages in the history of paleontology and museums, and that Italian influence extended strongly into northern Europe and the British Isles.

For example, Steno, or Niels Stensen, was a Danish cleric, but his scientific career was mostly Italian in locale, patronage, and material (Scherz, 1969, 1971); Olaus Worm, also Danish, probably was influenced by Aldrovandi in forming his museum (Schepelern, 1990:82); Aldrovandi's pioneering catalogs of his collection were emulated and cited frequently in much later catalogs in England (Grew, 1681; Sloane, see Thackray, 1994:125); and John Ray visited and was much impressed by Aldrovandi's collection (Torrens, 1985:206). Steno's work was immediately translated into English by Oldenburg, and it became the subject of great interest in the Royal Society (Eyles, 1958; Stokes, 1969:16). (Hooke accused Oldenburg and Steno of conspiring to plagiarize his ideas (Oldroyd, 1989:217); Drake (1996:116–117), especially, supported Hooke's claims, and, more importantly, documented his widely undersung contributions.)

It has been suggested (e.g., Rudwick, 1976:39–41; Torrens, 1985:207) that recognition of fossils as remains of once-living organisms occurred in Italy before it did in northern Europe and England because the Italian fossils were "easy," being geologically young, little altered, and close to the sea and to living relatives, whereas those elsewhere were much older, in deformed inland rocks, and the most conspicuous fossils were not closely related to living forms. Unfortunately, these factors can at best only partially explain away the Italian preeminence. Surely at least as important was the existence of an affluent society, with concomitant cultural sophistication, ready to underwrite research and to accept truth through logical argument. Gould (1997) presented a convenient and timely analysis of Leonardo's brilliant and prescient insights on fossils, well fixed in the context of time and place. Both geologic and human history preadapted Italy as the scene of these breakthroughs, and just as they were interwoven with a rich tapestry of culture, art, learning, and patronage, so also was the interrelated development of natural history collections. The literature in English reveals little comprehension of the fact that natural history museums developed (and survived in some cases) in continental Europe, especially in Italy, in some semblance of modern form, a century earlier than in the English-speaking world. It seems altogether too revealing that in 1995 I found the pages uncut in the Smithsonian Institution Library copy of MacGillivray's (1838) life of Aldrovandi. This neglect has been partially corrected in some excellent recent publications, including Impey and MacGregor (1985) and Findlen (1994). Ethnological and zoological objects from the Latin New World (then including Florida) have been well documented in these early collections (e.g., see Heikamp, 1976:458; Laurencich-Minelli, 1985), but to my knowledge no fossils have as yet been recognized. Nevertheless, the search for the beginnings of paleontology of the New World should begin in sixteenth century Italy, through direct examination of collections by appropriate specialists. The best hope might well be the collections of the great Ulisse (Latinized as Ulyssis) Aldrovandi (1522–1605), who was known to have had a strong interest in the New World (Heikamp, 1976:458; Laurencich-Minelli and Serra, 1988). His catalogs, largely compiled during his lifetime but published posthumously (Ambrosinus, 1648; Figure 1), remained a powerful influence long afterward in England (see above).


FIGURE 1.—Title page (much reduced) of Aldrovandi's 1648 monumental catalog of his museum. It was compiled and was widely known during his lifetime (1522–1605) but was published by Ambrosinus more than 40 years after Aldrovandi's death (Findlen, 1994:25).

## Some Early Records

This brings me to the first instances to be added to early reports of fossils from the Atlantic coast of North America. As early as 1669 an allusion was made to natural history specimens from Virginia in a collection, long since forgotten and irretrievably lost, maintained by the East India Company at its headquarters in London (Hunter, 1985:162). The first explicit record to be added is that by Nehemiah Grew, who in 1681 published by subscription under auspices of the Royal Society a catalog of its collections, the title page of which is reproduced herein (Figure 2; see Hunter, 1989, especially p. 142 et sqq., for genesis and nature of the catalog; see LeFanu, 1990, for Grew's life and contributions; see Clark, 1992, for an authoritative guide to histories of the society, its periodical publications, and indices thereto). Included are two entries for fossils specifically stated to have come from the New World.

> A sort of MUSCULITES fill'd with Earth like *Tobacco-Pipe* Clay or Marle. Found amongst the earth of a Hill that was overturn'd at *Kenebank* in *New England.* (Grew, 1681:264)

> A great petrify'd SCALLOP. Figur'd by *Ambrosinus* (*b*) with the Name of *Hippopectinites.* Given with several more of the same bigness, by Mr. _____ *Wicks.* 'Tis half a foot over. Many of the same kind were taken out of a great Rock in *Virginia,* forty miles from *Sea* or *River.* (Grew, 1681:262)

> (*b*) Aldrov. Mus. Metall. (Grew, 1681:262, marginal citation)

The first of these undoubtedly was a mussel shell, common in the late Pleistocene marine clays of the Presumpscot Formation of coastal Maine, including the vicinity of Kennebunk (Stuiver and Borns, 1975; Thompson, 1982:212, 226). John Winthrop, Jr. (1606–1676), an original fellow and major contributor to the society's repository (Lyons, 1944:50, 64; Stearns, 1951:196, 212, 246, 1970:117–139), undoubtedly was the source of the specimen in question. In letters of 11 October 1670, printed in part in Birch (1756(2):473–474) and quoted in part by Stearns (1970:137), he alluded to "small shells" among the objects sent from a "hill near Kennebeck, Me, that turned over in summer last (June or July) into the River." The mysterious "blowing-up" of the hill was reported also by John Josselyn (1674:210; see also White, 1956:180).

The second entry is potentially of much greater interest. The marginal bibliographic citation is to Aldrovandi's monumental, classic illustrated catalog (Ambrosinus, 1648), which Grew cited repeatedly, in this case alluding to a giant pecten illustrated on page 832 of volume 4. This raised the intriguing possibility that Aldrovandi's specimen might conceivably be a previously unsuspected and much earlier example from the New World. Unfortunately, my limited investigation to date has revealed no positive evidence that the giant pecten or any of Aldrovandi's fossils came from America; rather, Grew's allusion seems to be only an obsolete, broadly conceived synonymy, understandable for the time. The specimen has not been found among surviving collections in Bologna, but it is thought to have come from the vicinity of the city (Sarti, in litt., 1993).

Returning to Grew's specimens from Virginia, I had previously been inclined to accept the argument that the specimen of giant pecten, *Chesapecten jeffersonius,* described and illustrated by Lister, the first fossil so far known of any kind from the New World to be described and illustrated, probably had been collected by John Banister and sent directly to Lister, Petiver, or Sloane (see Ray, 1987:2), but now the Royal Society's Repository seems at least as likely. Not only was Lister's specimen "half a foot over," but also Lister (1639–1712) and Grew (1641–1712) coincided in their activities in the Society (Hunter, 1994:188–189), and Lister is known to have used other specimens from the repository.

The history of the repository is of great interest, not only in attempting to locate a potential historical treasure such as the giant pecten but also for its cautionary lessons to museologists in general. Early impetus to the establishment and support of the collection came from the need for a substantive rallying point for the struggling Royal Society and for a source of public prestige (Hunter, 1985, 1989:127, 128). Explicit and strikingly modern statements of the purposes of natural history collections were made by Grew (1681, preface), who advocated collections as an inventory of nature and as documentation of the ordinary, and by Hooke (1635–1703), who also took an active and at times official role in connection with the collections (see especially Hunter, 1989:125, 127, 139–141), and whose pioneering studies of fossil cephalopods stimulated his following statements (1705:338; also in Drake, 1996:236–237):

> And indeed it is not only in the description of this Species of Shells and Fishes, that a very great Defect or Imperfection may be found among Natural Historians, but in the Description of most other things; so that without inspection of the things themselves, a Man is but a very little wiser. ... It were therefore much to be wisht for and indeavoured that there might be made and kept in some Repository as full and compleat a Collection of all varieties of Natural Bodies as could be obtained, where an Inquirer might be able to have recourse, where he might peruse, and turn over, and spell, and read the Book of Nature, and observe the *Orthography, Etymologia, Syntaxis* and *Prosodia* of Nature's Grammar, and by which, as with a *Dictionary,* he might readily turn to and find the true Figure, Composition, Derivation and Use of the Characters, Words, Phrases and Sentences of Nature written with indelible, and most exact, and most expressive Letters, without which Books it will be very difficult to be thoroughly a *Literatus* in the Language and Sense of Nature. The use of such a Collection is not for Divertisement, and Wonder, and Gazing, as 'tis for the most part thought and esteemed, and like Pictures for Children to admire and be pleased with, but for the most serious and diligent study of the most able Proficient in Natural Philosophy. And upon this occasion tho' it be a digression, I could heartily wish that a Collection were made in this Repository of as many varieties as could be produced of these kinds of Fossile-Shells and Petrifactions, which would be no very difficult matter to be done if anyone made it his care.

Despite these and other resounding statements within the society, the reality (dictated largely by its dilettante membership) was that its collection continued to be much like that of a private cabinet of curiosities—devoted to the rare and bizarre rather than being a microcosm of what exists, ordinary as well as extraordinary (Hunter, 1989:150). This tension has yet to be resolved in museums, although the "inventory of nature" movement seems to be gaining ascendancy at last. Further, the society found that although establishing a museum is easy, maintaining it in the long term ("perpetuity") is almost impossible. From the beginning, much of the society's attention was

*MUSÆUM REGALIS SOCIETATIS.*

OR A

# Catalogue & Deſcription

Of the Natural and Artificial

# RARITIES

Belonging to the

# ROYAL SOCIETY

And preſerved at

# Greſham Colledge.

MADE

By *Nehemjah Grew* M. D. Fellow of the *Royal Society*, and of the *Colledge* of *Phyſitians*.

Whereunto is Subjoyned the

# Comparative Anatomy

OF

# Stomachs and Guts.

*By the ſame AUTHOR.*

*LONDON,*

Printed by *W. Rawlins*, for the Author, 1681.

FIGURE 2.—Title page (reduced) of Grew's 1681 catalog of the repository of the Royal Society.

usurped by monetary problems, including difficulty in collecting dues and shortfall in funds to pay support staff. After years of vicissitudes in the care of its collections that entailed repeated efforts at revitalization, and finally faced with a critical problem in space to house the collection, the society offered its collections to the British Museum in 1779 (Hunter, 1989:153–155), which accepted in 1781 (Lyons, 1944:211). Now, a mere two centuries later, the heir to that collection, The Natural History Museum (BMNH), London, the Gibralter of its kind, itself faces an uncertain future (e.g., see *Nature,* 1990), as do its counterparts elsewhere (Trescott, 1996; Butler, 1997).

In any case, the "several" giant pecten(s) from Virginia should have gone in 1781 to the British Museum. Although it seems unlikely that such large, conspicuous shells would have been lost, sold, or destroyed, even in the vandalous "cremations" of curator Shaw (Stearn, 1981:17), they have not as yet been recognized in the existing collections of BMNH (Nuttall, in litt., 1993).

The specimens in all probability represent *Chesapecten jeffersonius* (see Ray, 1987), since 1993 the official fossil of the Commonwealth of Virginia (Anonymous, 1993) and thus of great historic and current interest if found.

This leaves only the matter of the donor, "Mr. _____ Wicks," who turns out to be a subject of specific and general interest in spite of the paucity of information about him. The person in question undoubtedly is Michael Wicks, clerk of the Royal Society for at least 20 years (Thomson, 1812:15, lists his years in office as 23), from the first meeting of the council on 13 May 1663 (Birch, 1756(1):236) at least until 27 November 1683, when it was resolved that "Mr. Cramer be clerk to the society in Wicks's place" and that "Mr. Wicks be told, that his attendance is of no farther use" (Birch, 1757(4):229). This resolution seems however not to have had the finality that it implied, as Mr. Wicks was given orders at the meeting of 2 April 1684, and the treasurer was ordered on 14 January 1685 to pay him "fifteen pounds for a year and a half's salary" (Birch, 1757(4):277, 355). Robinson (1946:194–195) gave a summary of Wicks' employment by the society, indicating that the last mention of him is that of 13 November 1695, when a gratuity was voted him by the Council; however, Hunter (1994:235) noted a substantial payment to him as late as 1696. It should be noted that Robinson refers to Wicks as "Weeks," that he appears as "John Weeks" in Weld (1848:562), secondarily as "Weekes" in Hunter (1994:235), and is omitted altogether by Lyons (1940:344).

Apparently prior to Wicks' appointment with the society, Dr. Jonathan Goddard (1617–1675, professor at Gresham College) had employed "Mr. Mich. Weekes, who looked to his stills" (Aubrey, 1898(1):268). In this case, the stills were for production of ingredients to various secret medicinal nostra. It is thought that Wicks got the job as clerk through Goddard's influence (Robinson, 1946:194). This seems plausible in view of Goddard's major role in the birth and early development of the society, from its unchartered gestation, beginning in 1645 (Copeman, 1960; McKie, 1960), through the turbulent period of the Civil War, Commonwealth, and Protectorate (inauspicious for the founding of anything "Royal").

In John Aubrey's (1626–1697) notes (dated 12 March 1689) for his brief life of Walter Raleigh, in connection with Raleigh's role in introducing tobacco to England, he states (Aubrey, 1898(2):181–182),

> Mr. [Michael] Weekes, register[a] of the Royal Society and an officer of the custome-house, does assure me that the customes of tobacco over all England is four hundred thousand pounds per annum.
>
> [a]Subst. for 'clerk.'

There can be no doubt that Weekes and Michael Wicks are one and the same person. In response to my queries regarding Wicks, Mary Sampson (pers. comm., 1993), archivist to the Royal Society, found only one written communication by Wicks in the society's unpublished Classified Papers series (CL. P. XXIV.56), a brief undated note of some 13 lines, addressed to Henry Oldenburg (his boss). I have been unable to decipher the handwritten note entirely, but the gist of it is that he put out some papers for Oldenburg stating, "I am sorry I could not wait upon you sooner, my business at Custome House being much more than ordinary."

In 1993, Gillian Hughes, an independent researcher, undertook on my behalf a preliminary search in the Public Record Office for evidence of Michael Wicks in the Customs Establishment. The earliest certain indication found by her lists Michael Wicks as Receiver for the Plantations among officers of his majesty's customes for 1673 and 1675 (PRO 30/32/15 and 17), and his name was last seen in those lists for 1693 (PRO, CUST 18/28). In the published *Calendar of Treasury Books* (Shaw, 1935:584), allusion is made under the date 17 April 1694 to "Mich. Wicks, late Receiver of the Plantation Duties and of the new impositions on tobacco and sugar... lately discharged from that service." The *Calendar of Treasury Papers* (Redington, 1868:338) indicates "confusion in the accounts of Mr. Wicks," and the Commissioners of Customs "describe their perplexities about his accounts, and that to prevent further enlargement they had dispensed with his attendance at the Custom House.... Dated 5 Jan. 1693 [now 1694]."

Thus it seems clear that Michael Wicks (up to his dismissal under a cloud) was in an unusually favorable position for direct, frequent communication with merchant ships sailing to and from British America. At the meeting of the Royal Society on 13 June 1683, "Mr. WICKS was desired to procure from the East-India ships a quantity of the shining sand of St. Christopher's and James river in Virginia" (Birch, 1757(4):209). This request would hardly have been made had it not been anticipated that Wicks could accommodate it.

Interestingly, this is the only instance in the long employment of Wicks by the society in which he was "desired" to do something, rather than "ordered" or "directed." This is probably not accidental, but reflects a momentary deference to his position with the custom house. Otherwise, paid subordinates were addressed in the imperative, whereas the gentlemen Fel-

lows were "requested" or "desired" to do something. Pumfrey (1991:12–16; Drake, 1996:17–18, 104–105, not withstanding) has made a persuasive case for this distinction in connection with his study of Robert Hooke's precarious position betwixt and between, which may have contributed to Hooke's apparently atypical egalitarian attitude toward subordinates (e.g., see Shapin, 1989:269), as well as to his prickly attitude toward the establishment.

It should be recognized that the society's treatment of Wicks was not cruel and unusual but was in general correct for the social system of the time and place. Even allowing for the free-wheeling attitude toward spelling in those days, it apparently was not important to get his name right or even to include it consistently in society records, nor perhaps was it important for Grew to remember or later insert Wicks's given name in the manuscript for the society's catalog.

The next explicit report of specimens from the Atlantic Coastal Plain is that of Sloane (1697). He borrowed the specimens from his friend, Dr. Tancred Robinson, who had just received them from Maryland (most likely from the Rev. Hugh Jones, who arrived there in 1696 and was accused by Woodward of sending specimens to "rogues and rascalls," including Sloane, Petiver, Lister, and Robinson (Stearns, 1952:292, 306)). These specimens included at least three isolated tooth plates of the ray *Aetobatis,* illustrated in Sloane's figs. 7–12; it is unclear from his text whether the articulated partial tooth battery shown in his figs. 13 and 14 also is from Maryland (see Figure 3). At least the fragmental plate shown in his figs. 7 and 10 is among the very small number of the founder's specimens known to survive in BMNH, where it was featured in an exhibition on the history of paleontology (Edwards, 1931:61) and where it apparently is still to be found (Thackray, 1994:132). Obviously Robinson must have allowed Sloane to retain at least one of the fossils. Some or all of the others may be preserved in Woodward's collection at Cambridge. In an appendix to his primary catalog of English "extraneous" fossils (catalog B of Price, 1989:94), however, Woodward (1728–1729) listed modern specimens preserved for comparison to his fossils, and on page 111, under his entry number 25, a modern ray dentition, he expressly stated that his ray tooth plates sent by Jones from Maryland "were digg'd up, together with those" reported by Sloane (see catalog B of Price, 1989).

Sir Hans Sloane (1650–1753) is best known as a prodigious collector who provided the foundation for the collections of the British Museum and its offshoots. He also was a man of parts who was a successful doctor of medicine, an olympian letter writer, and a major force in the Royal Society, although he was not without his detractors, most notably John Woodward (e.g., see MacGregor, 1994:19). Most have made light of his abilities as a thinker and researcher. Nevertheless, his little paper on the fossil ray plates is an elegant example of modernity produced before any pattern was established. He placed the isolated unknowns (considered by some to be bits of petrified mushrooms) alongside the most appropriate specimens of known identity, articulated and disarticulated modern ray tooth batteries, found them to be similar in detail, illustrated them accurately in comparable orientations, and concluded that they derived from identical or closely related organisms. One's first impulse today might be to dismiss this approach as routine, but it was not such in the context of the time. Although spectacular examples of brilliant comparative methodology are known here and there from the sixteenth century onward (note that Grew used the approach and the term, "comparative anatomy," in 1681, see Figure 2), the techniques were not codified and universally applied until the nineteenth century under the influence of Cuvier, Owen, and Agassiz. This could not have occurred prior to the Age of Enlightenment/Reason, with the spread of the notion that all problems could be successfully solved through intensive inspection and that ordinary humans could rely on their own careful observations irrespective of authority. This approach was the cornerstone of the Royal Society. Until recently, this reliance was taken for granted, so much so that the sublime notion could be expressed profanely, if I may be permitted one homely example: Remington Kellogg, once asked by a colleague what criteria allowed him to conclude that a certain fragmentary whale vertebra was in fact identifiable to a particular species, immediately replied resoundingly, "because it looks like it, goddamit it!" He did not live to experience the postmodern entry of doubt introduced by phylogenetic systematics and social constructivism, in which we question the meaning of all our observations.

Further, Sloane's (1697) note was written when the nature of fossils as vestiges of once-living organisms had by no means been universally accepted by serious scholars. This topic brings us conveniently to the next known report and illustration of fossils from the Atlantic Coastal Plain, that of a bone fragment and a shark tooth by Scheuchzer (1708), whose title page and figures are reproduced herein (Figures 4–6). Both specimens are preserved in the Paleontological Museum of Zürich (Leu, in litt., 1997; see also Furrer and Lev, 1998:33).

Johann Jacob Scheuchzer (1672–1733), little familiar to the English-speaking scientific community, is known primarily as an object of derision for his *Homo diluvii testis* faux pas, based on a fossil salamander (see Jahn, 1969, for this and for a good thumbnail biography of Scheuchzer in English). Scheuchzer was actually a very substantial scientist who translated Woodward into Latin and promoted his ideas (notably organic origin of fossils) on the continent. Scheuchzer was in close contact with Sloane and other leading naturalists of the Royal Society. His historical significance would unquestionably be better appreciated had Jahn's (1975) promised bio-bibliography of Scheuchzer and translations of his major works materialized.

The bone fragment from Maryland was attributed by Scheuchzer (1708:22) to the acetabular region of the innominate bone of a mammal ("Animalis"), not a farfetched supposition. This fragment, however, matches very well the portion of a small cetacean atlas vertebra that characteristically remains after the vertebra breaks at the weak points and rolls on the beach; it is illustrated (Figure 5) alongside a typical float specimen and a well-preserved atlas from the Miocene of Chesa-

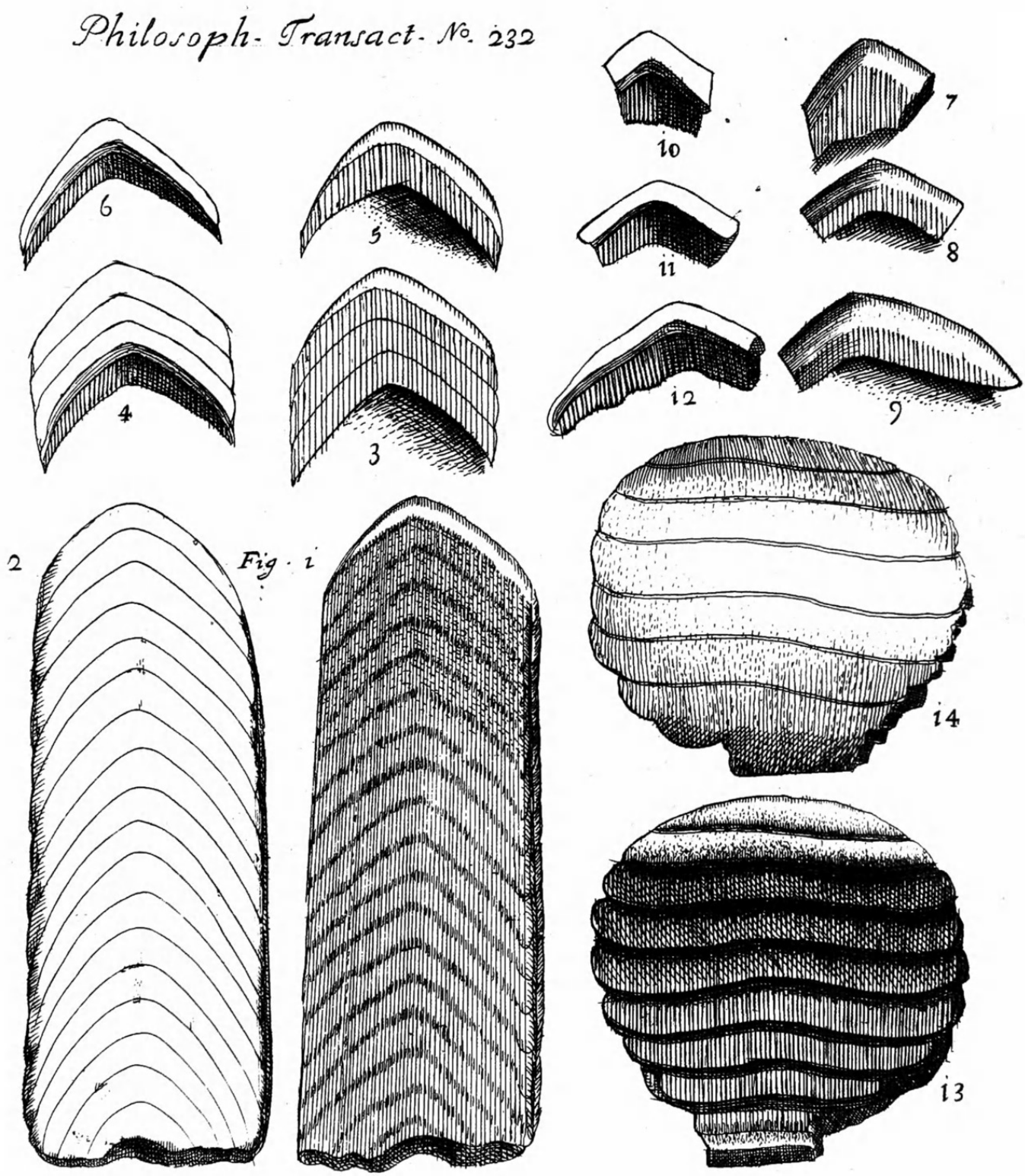
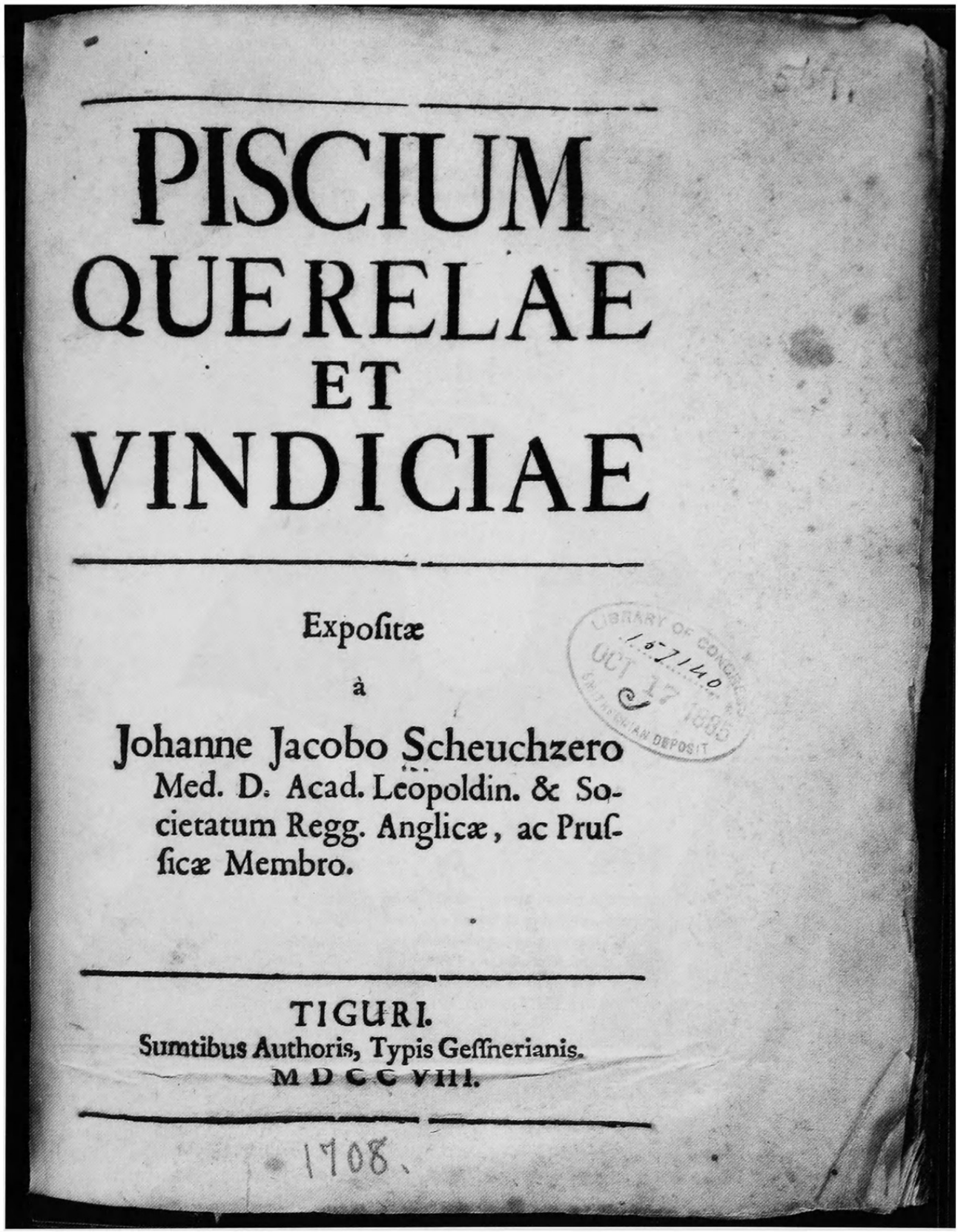



FIGURE 3.—Plate accompanying Sloane's 1697 report on fossil ray teeth from Maryland (×1). His figures 1–6 are of modern species, figures 7–12 are of fossil species from Maryland, and figures 13–14 are of fossils from an unknown locality, possibly Maryland.

peake Bay in Maryland. This is probably the first cetacean (and mammalian) fossil from America to be illustrated.

This Maryland specimen, especially if received by Scheuchzer from Petiver, probably was sent by Hugh Jones. Lhwyd (1660–1709) complained that Petiver and his pal Doody got aboard ship and rifled collections from Jones intended for him (Gunther, 1945:343, 462). Among specimens cataloged by Sloane that came to him in Petiver's collection were "shark


PISCIUM
QUERELAE
ET
VINDICIAE

Expoſitæ

à

Johanne Jacobo Scheuchzero
Med. D. Acad. Leopoldin. & Societatum Regg. Anglicæ, ac Pruſſicæ Membro.

TIGURI.
Sumtibus Authoris, Typis Geſſnerianis.
M D C C VIII.

1708.



FIGURE 4.—Title page of Scheuchzer's 1708 classic, *Piscium Querelae et Vindiciae* (×1).

teeth and other fossils sent from Maryland by the Revd Hugh Jones" (Thackray, 1994:126). Jones communicated especially with Petiver and sent specimens from Maryland at least from 1696 to 1702, although he became ill in 1700. Jones had gotten his job as chaplain to the governor of Maryland through the initial recommendation of Lhwyd, furthered by the Temple Coffee House group that included Sloane, Petiver, Doody, Lister, and Robinson (Stearns, 1952:292–294; Jessop, 1989).

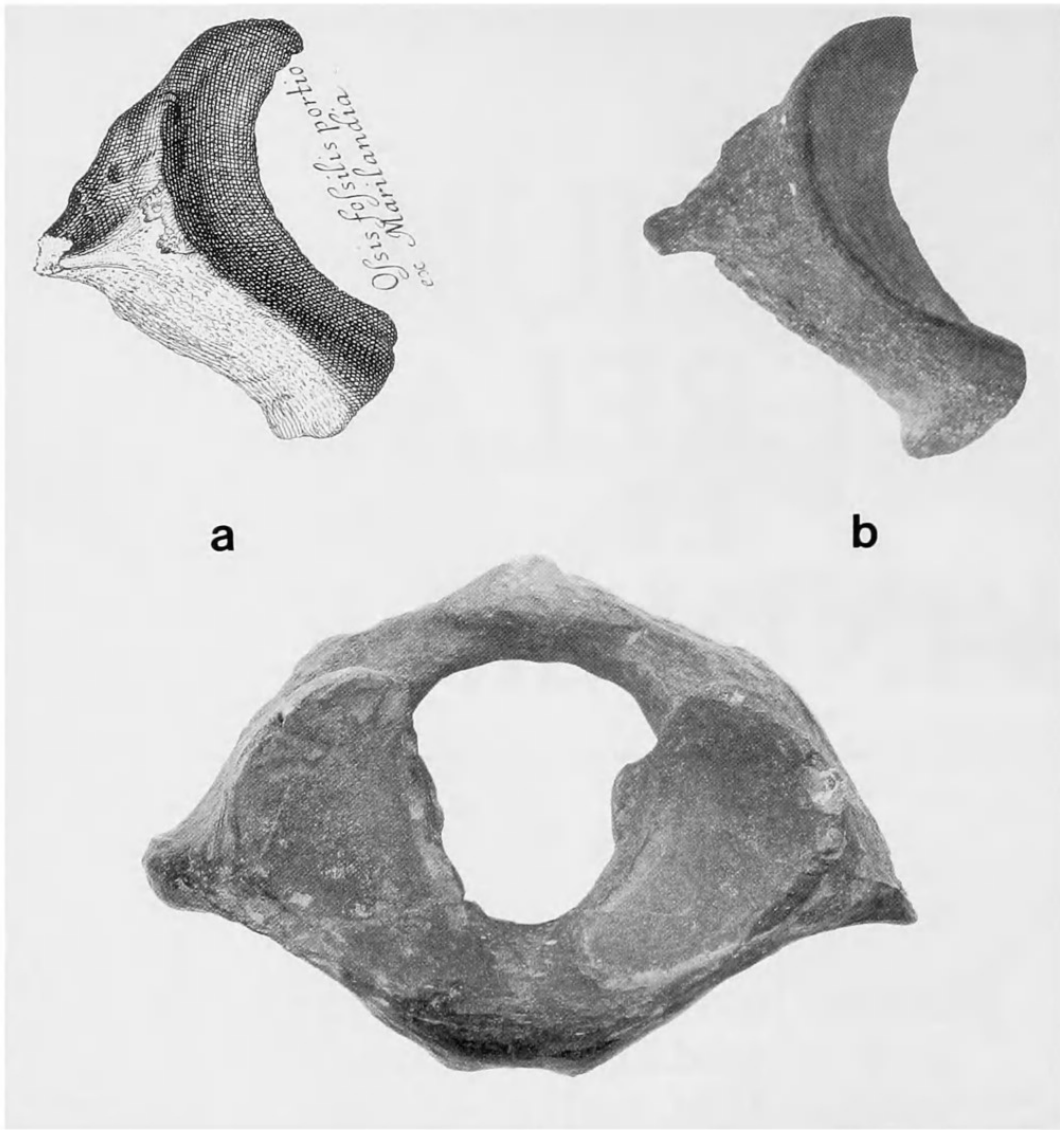



FIGURE 5.—Cetacean atlas vertebrae in cranial aspect (×0.82), *a*, Scheuchzer's figure reproduced; *b*, similar waterworn fragment, *Lophocetus* sp., probably collected on beach in Calvert County, Maryland, USNM 449525 (National Museum of Natural History, Smithsonian Institution, which houses collections of the former United States National Museum); *c*, complete atlas, Cove Point, Calvert County, Maryland, St. Marys Formation, collected by Francis Markoe, Jr., 1841, part of the holotype of *Lophocetus calvertensis* (Harlan), itself a historic specimen (Gilmore, 1941:311–312, 377; Simpson, 1942:162, 176). (Scale bar=1 cm.)

The second specimen, an incomplete tooth of *Carcharodon megalodon* Agassiz from the Carolinas (Figure 6*a*), is described by Scheuchzer (1708:20) as lacking serrations. The absence of serrations is of no taxonomic significance because the tooth is clearly waterworn and is typical of the rolled specimens so abundant in the lower reaches of several rivers in South Carolina.

Scheuchzer's comparison was to Luid number 1259, a similarly waterworn specimen from the British Crag (Figure 6*c*). The number refers to the collection of Edward Lhwyd, Latinized as Luid, among the many variations of the surname (see Gunther, 1945:vii) (see Roberts, 1989, for a succinct biography), whose specimen survives in the geological collections at the University Museum, Oxford (Powell, in litt., 1993). Scheuchzer's inferred outline of his incomplete specimen is a very early example of paleontological restoration, however modest.

Jacob (or James) Petiver (?1663–1718), identified as the donor, was a London pharmacist and perhaps second only to Sloane as a natural history collector and letter writer (see Stearns, 1952, for the fullest account of Petiver). Of course, Lhwyd and Woodward outdid Petiver in their geological collections (Torrens, 1985).

Petiver's most productive correspondent in South Carolina was the Rev. Joseph Lord, who began sending him specimens in 1701 and continued at least until 1713 (Stearns, 1952:346, 362). Especially relevant may be Petiver's (1705:1960) account of two fossil shark teeth sent by Lord,

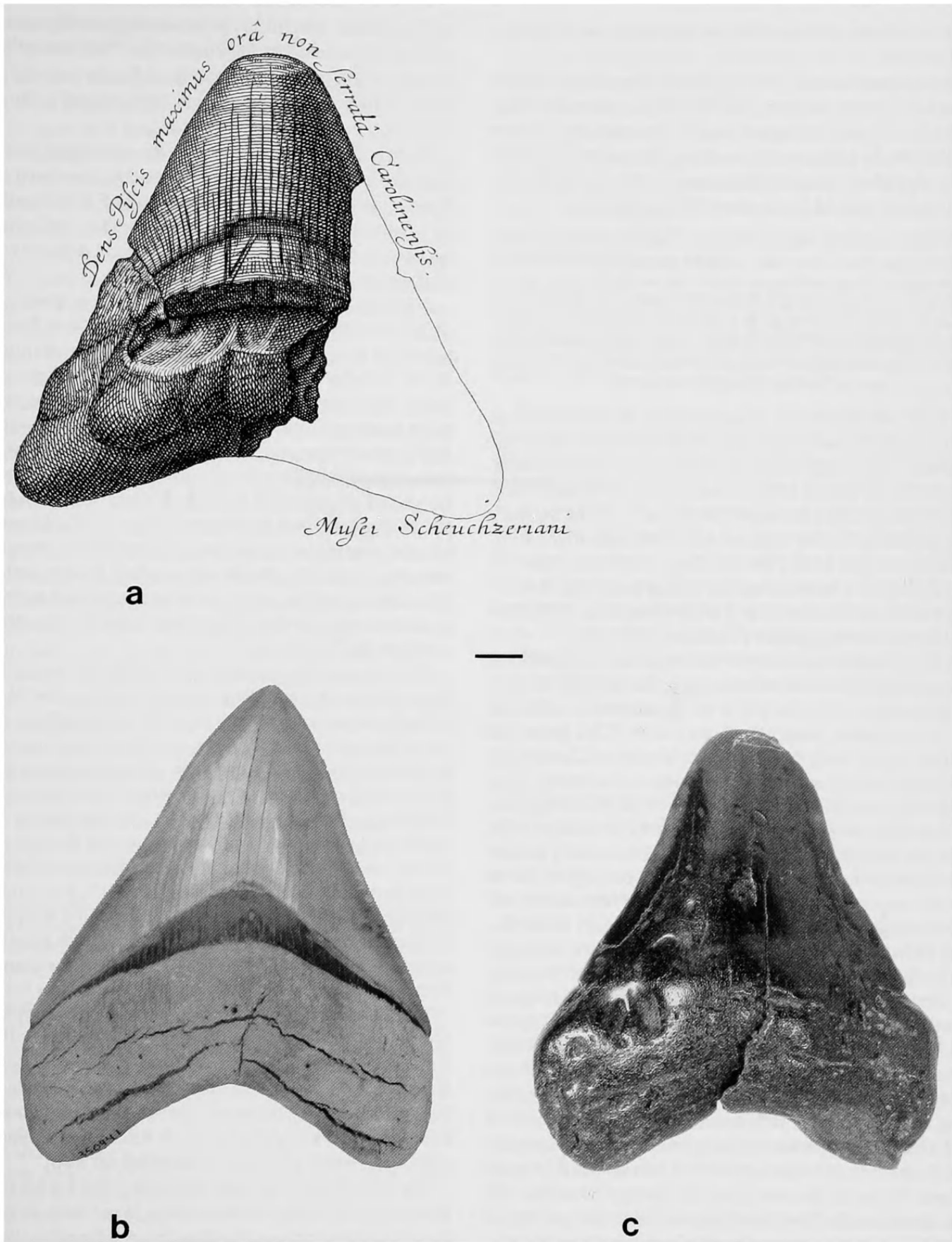



FIGURE 6.—Teeth of *Carcharodon megalodon* (×0.82), *a,* Scheuchzer's figure reproduced; *b,* well-preserved tooth, showing serrations, collected by P.J. Harmatuk, from Yorktown Formation spoil, Lee Creek Mine, North Carolina, USNM 350941; *c,* waterworn specimen, probably from the bone bed at the base of the Red Crag, Suffolk, England (H.P. Powell, in litt., 1993), Lhwyd collection number 1259, Oxford University Museum, photograph courtesy of Oxford University Museum of Natural History. (Scale bar=1 cm.)

the first of which could possibly be the very one illustrated by Scheuchzer.

Here may be mentioned what is probably the earliest allusion to a fossil of a bony fish from the New World, other than Winthrop's 1636 allusion to "Fishes' bones" from the James River (Ray, 1983:4). In a letter to Petiver from his home at Dorchester (this would have been old Dorchester on the Ashley River), South Carolina, dated 1 September 1707, Lord writes:

> Herewith comes a small box with divers Fossils. ... In a part of my land where some were digging after a sort of Marl ... a stone was digged, somewhat flat & broad, but looking like ye marl among which it lay, on which was ye tail of a small fish & ye body near as far as ye Navel, of a brown colour, shewing fins & scales very apparently, but all Stone; & it seemed so distinct that I had a conceit I might separate it from ye rest of ye Stone, which I endeavoured to no purpose, but in trying much defaced ye Impress; & since, only lying in my Study made it more obscure: but however I have put it into ye Box.

The letter was marked as received on 26 January 1708, as was presumably the accompanying small box. The original letter is preserved among the Sloane manuscripts (Sloane 4064, folio 150) in the British Library (permission to quote not required; Taylor, in litt., 25 April 1994) as a result of Sloane's having purchased Petiver's papers and collections after the latter's death (Stearns, 1952:244; MacGregor, 1994:23). The fossil fish should have been among the Sloane specimens that initiated the British Museum, but if it survives in the BMNH, it has not as yet been recognized (Thackray, 1994:132).

In striking contrast to the loss or unknown fate of most North American fossils from the colonial era is the survival of those in the Scheuchzer collection and in the incomparable collection of his correspondent, John Woodward (1665–1728), preserved essentially intact, with data, at the University of Cambridge. The essential background to this collection can be learned from Woodward's own catalogs (Woodward, 1728–1729), Gunther (1937:424–433), and especially Price (1989). A measure of its volume and significance can be gained from the catalog entries. The North American fossils are contained in catalogs K and M of Price's notation (1989:93–94; table 1). Of 655 catalog entries for foreign fossils (only fossils in the modern sense, excluding rocks and minerals), 74 are North American; these represent a minimum of 127 of the total 1210 specimens. Thus, the North American material constitutes more than 10 percent of both total catalog numbers and specimens. Of the 127 specimens, 74 are invertebrates, mostly mollusks, and 53 are vertebrates, mostly sharks' teeth. Of the 74 catalog entries, 51 are from Maryland and 23 are from Virginia. Among the Maryland entries, at least 27 are attributed to William Vernon, 18 to Hugh Jones, and three to David Krieg, the three most important names in seventeenth-century natural history collecting in Maryland. Although focused primarily on their botanical collecting, the account of their activities in Maryland by Frick et al. (1987) is a convenient and authoritative source (see also Stearns, 1970:264–274). Jones, as previously noted, spanned the years 1696–1702 but was largely incapacitated for the last two. Vernon and Krieg overlapped almost exactly in their brief visits, during the spring and summer of 1698. There was keen interest and competition, in part unfriendly, among British naturalists for the specimens. Woodward, generally at odds with most of his contemporaries, boasted that "Mr. Doody had given him all or the greatest part of those fossils you [Jones] sent him" (Petiver to Jones, 10 March 1698; quoted in Frick et al., 1987:19; see also Stearns, 1970:265).

Of three catalog entries for Virginia specimens attributed to John Banister, two are explicitly stated to have been given by Doody, clearly a continuing benefactor of Woodward. Banister's collecting could not have been later than 1692, the year of his death (see Ewan and Ewan, 1970, for a definitive account of Banister).

All of the 20 North American entries (19 mollusks, 1 barnacle) in Woodward's additional list (catalog M of Price, 1989) pertain to what was probably a single locality near the James River, 20 miles (~32 km) above its mouth. One specimen was found "by Lyons-Creek" (now Lawnes Creek, reverting to the place names of Christopher Lawne's Plantation, established in 1619), which empties into the James River just below Hog Island, opposite Williamsburg, some 20 miles (~32 km) up the James. All are attributed to a "Mr. Miller," who is probably the Mr. Miller described by Hearne (Salter, 1915:148) as Woodward's "neighbor & particular Acquaintance for 30 years past, who often went abroad with him to gather Fossils, and assisted him often in packing up boxes, to be sent abroad to Professors & curious persons, & presented him himself with a Drawer or two from the West Indies."

With the possible exception of the Miller specimens from the James River, all North American specimens in the Woodward collection were collected prior to 1700. Judging from the identity of the collectors, their time, and Woodward's annotations, it seems highly probable that some of the specimens may have been studied or illustrated by Banister, Lister, Sloane, or contemporaries. Price's valuable studies, cut short by his untimely death, were only just beginning to reveal the value of this unique resource, and it has not been feasible to examine the collection firsthand for the present project. Close study of the specimens with relevant literature at hand could scarcely fail to yield interesting results. Some of the shark teeth have been examined recently by Shelton P. Applegate of the Universidad Nacional Autonoma de México.

The majority of the remaining entries for foreign fossils in Woodward's catalogs (catalogs K and M of Price, 1989) are from the extremely important collections of Scilla and Scheuchzer. Woodward appears to have been meticulous in citing their specimens, but as yet none of his entries for them can be identified as pertaining to North American specimens. The collection should, of course, be searched for them.

The next instance of early collecting that I wish to note is from a letter to Peter Collinson from John Custis of Williamsburg, Virginia, believed to have been written on 28 August 1737. In it Custis alludes to the extreme drought of that summer, which necessitated his digging a deep well to water his garden. The letter is quoted in part from Swem (1957:47):

> As you are a very curious gentleman I send you some things which I took out of the bottom of A well 40 feet deep; The one seems to bee a cockle petre-

fyd one a bone petrefyd; [this?] seems to have been the under beak of some large antediluvian fowl. Wish they may bee acceptable.

In a letter of 5 December 1737, Collinson thanked Custis for "the Curious Fossils that you sent Mee last year" (Swem, 1957:60); again, in a letter of 5 March 1741 (Swem, 1957:71), Collinson alludes to fossils sent by Custis as "shells that was found so Deep when you was Makeing the Mill Dam." At least some of these fossils were on exhibit at Mill Hill School, on the site of Collinson's home, near London, in the early 1930s, but they have been lost sight of since (Swem, 1957:172; Hume, 1994:22). Interestingly, the 1964 archaeological reexcavation of Custis' 40-foot (~12 m) well in Colonial Williamsburg, Virginia, yielded fossil shells and whale bones (Hume, 1994:20, 22). All of these specimens undoubtedly derive from the Pliocene Yorktown Formation.

John Custis (1678–1749), educated in England, was a prominent citizen of Virginia and an avid horticulturist, which led to his association with Peter Collinson (Swem, 1957:11–20). Collinson (1694–1768) was a successful business man with extensive interests in the American colonies, including a lifelong avocation to botany (Swem, 1957:1–9). He was singled out by Stearns (1951:194–195) as one of the most active fellows of the Royal Society in encouraging North American naturalists. He is perhaps best known in North America in connection with the vertebrate fossils of Big Bone Lick, Kentucky (Jillson, 1936; Simpson, 1943). Although Collinson was especially active in adding to Sloane's collection (Swem, 1957:3), no evidence has yet emerged to identify any fossils from Custis' digging in Williamsburg in the surviving collections of BMNH.

Lastly, although much later than the other reports cited herein, I wish to supplement my earlier account (Ray, 1983:6–7) of Latrobe's 1799 report of vertebrate fossils from Richmond, Virginia, including sharks' teeth, fish vertebrae, a large bird femur, and a partial porpoise flipper. Latrobe (1809:283–284) returned to this subject as follows:

> It was my intention then, to have offered to the [American Philosophical] Society, a series of geological papers, the materials of which I had collected, and of which this memoir [Latrobe, 1799] was the first. But my intention was delayed and partly defeated by the loss of a very large collection of all the principal fossils, necessary to elucidate my observations, in their passage by water, from Fredericksburg to Philadelphia.—This collection, intended for the American Philosophical Society, was made by the industry of my excellent friends, Mr. William Maclure now at Paris, of the late Dr. Scandella whose untimely death in 1798 science and friendship equally have to deplore, and of myself.—It consisted of specimens of loose and undecayed fossil shells, found on and near *the surface*, from the coast to the falls of the rivers of Virginia, of the shell rocks of York river, of the clays with impressions of shells in every fracture, but which shew no remaining evidence of any calcareous matter when subjected to chemical tests; of the exuviae of sea animals*, bones of fishes, sharks' teeth, marsh mud, fossil wood and coral rock, dug from the deep wells about Richmond, of the marles of Pamunkey and Mattapony, of all the strata of the coal mines on James's river, of the varieties of the granite of Virginia, of the free stone of James's river and the Rappahannoc, with the vegetable petrefactions and coal belong to it; and of a variety of miscellaneous fossils. ... The loss of this collection dispirited me, and the occupations of a most labourious profession deprived me of time.
>
> *Drawings of some of the exuviae accompanied my memoir, to which refer.—The bones of the foot there represented, are probably those of a sea tortoise....

Had those collections survived and become available for research in Philadelphia, paleontology of the Atlantic Coastal Plain might have been advanced by some decades. In the same report Latrobe went on to discuss other geologic phenomena including delineation of the fall line and its significance in relation to building stones. He was a practical man whose job at that time was "Surveyor of the Public buildings of the U. States," (Latrobe, 1809:293), which makes his closing observation (Latrobe, 1809:292) regarding the geologic problems discussed all the more revealing:

> It is fortunate that the solution of these aenigmas of nature are of no consequence whatever to our happiness, or of use to our enjoyments.—But the pleasures of investigation, and of *wonder*, the offspring of ignorance, are not without a charm, which often entices the mere speculative philosopher into researches that produce results beneficial to mankind.

We continue to vacillate in the unresolved and unresolvable stress between applied and pure research. In the most recent cycle, support for pure research probably reached a peak in the expansive mood of prosperity during the 1960s, when science could save us. We may hope that the retrenchment of the 1990s, with its demand for quick returns and the rise of pseudoscience, is the nadir of the curve and not the precipitous slope of descent into continuing decay and rejection of science (see Sagan, 1995, especially chapters 14, 23, and 25, and Gross et al., 1996, for timely, accessible examinations of the problem; see Maull, 1997, for an example of the widespread and disastrous confounding of science and scientists by social constructivists).

## Conclusions

Review of these additional early publications on fossils from the Atlantic Coastal Plain leads to a few observations of seemingly wider relevance. These may be grouped conveniently for present purposes under the topics of "Firsts" for North America and for paleontology and of "Sharks' Teeth."

FIRSTS.—Simpson (1942, 1943) was among the very few practicing vertebrate paleontologists in the modern era to have looked seriously into the early history of the subject in North America. Here, too, should be mentioned the historical research by Helen Ann Warren, under the aegis of Henry Fairfield Osborn (in Osborn, 1931:ix, 1–33), which was similar in content and emphasis, if not in depth, to that of Simpson. Simpson was more than casually involved with preparation of the book (on Edward Drinker Cope) of which Warren's work was part, overlapped completely with her at the American Museum of Natural History (Osborn, 1931:ix), and may have relied too heavily on her spadework. Be that as it may, he brought together a great deal of scattered information and quite correctly contrasted casual or inconsequent early finds (such as those by early Indians—interesting but not contributing to science) with those that were to become factors in the advancement of knowledge in western culture. In his words, "true discovery [is] that leading by a traceable route, however devious, to eventual elucidation of the problems concerned" (Simpson,

1942:135), and again, "merely seeing a fossil bone or picking it up in idle curiosity is hardly discovery.... scientific discovery was that which initiated continuous consciousness and record of the occurrence of fossil animals in America and had the first scientific studies as its sequel" (Simpson, 1943:26–27).

Although these definitions are meaningful, Simpson was mistaken in every instance in applying them toward identification of firsts for North America, thus making his papers not the definitive work that he supposed (Simpson, 1943:26). Taking caution from his example, I do not propose that my candidates are in truth firsts, only that they are the earliest known to me (as indicated, I suspect, even hope, that there are still earlier ones, especially Italian, and thus I believe that the present account is not the last word). It must be emphasized that Simpson provides a large target only because he had the rare insight to see the value of history and the ability to draw so much together from scratch. His well-earned stature and authority make doubly important the correction of his objective errors. Further, those errors reflect what I believe to be a pervasive lack of comprehension among American paleontologists of the sophisticated nature of natural history investigations by western Europeans in the late seventeenth and early eighteenth centuries.

Simpson (1942:131) defined six periods in the history of vertebrate paleontology in America, the first two of which are of interest here.

> 1. *Pre-scientific Period.*—From the earliest times to about 1762. The first fossil discoveries were made. Toward the end of the period bones were collected and sent to Europe. No truly scientific study of them had been made.
>
> 2. *Proto-scientific Period.*—From about 1762 to about 1799. In 1762 Daubenton read a paper on American fossils treating them for the first time in what deserves to be called a scientific way.

In reference to Lord's 1707 letter to Petiver about the fossil fish tail (see "Some Early Records," above) Simpson stated (1942:135), "The incident is... unique for its date, and for a long time there after, in involving a *small* fossil vertebrate. Most of the eighteenth century naturalists overlooked bones of animals smaller than the mastodon. ..." Simpson (1943:27) regarded letters from Cotton Mather as the "first publication on American fossil vertebrates" (published in 1714 in the Royal Society's Philosophical Transactions), and Simpson thought they probably were based on mastodon remains. In allusion to Catesby's 1743 report of African slaves' recognition of fossil proboscidean teeth, Simpson (1942:134) credited them with the "first technical identification of an American fossil vertebrate," assuming the incident to have occurred prior to 1739. Based on the collection from Big Bone Lick, primarily of mastodon remains, Simpson stated (1942:135), "If Columbus discovered America in 1492, Charles Le Moyne, second Baron de Longueuil, discovered American fossil vertebrates in 1739." Simpson (1942:144–145) added that "Guettard (1756, read in 1752) published the first illustration of an American vertebrate fossil... [and] a decade later Daubenton (1764, read in 1762)... [provided]... an excellent example of the comparative method... one of the four most basic... principles in the rise of vertebrate paleontology and it may fairly be dated from Daubenton...." Both Guettard's and Daubenton's contributions stemmed from the 1739 Longueuil collection of mastodon remains.

Both Sloane (1697) and Scheuchzer (1708) conspicuously antedate Guettard for the first description and illustration of North American fossil vertebrates. Sloane's paper in particular meets every possible criterion: the fossils reported were collected through a purposive scientific program (about which more beyond); Sloane was among the most prominent natural historians of his or any other era; he published in the premier scientific journal in English; his title alone reveals the significance of his subject; the specimens are small, and at least one survives today; and the paper is a model of comparative methodology.

The larger point to be emphasized is the nature of the natural history enterprise in western Europe in the late seventeenth and early eighteenth centuries, for present purposes especially in England, and especially centered among fellows of the Royal Society. Their sustained, intensive, extensive interest in North America is well recognized and is woven into the modern literature of zoology and especially of botany (Stearns, 1970, and Frick et al., 1987, are superb examples) but is reflected hardly at all in that of paleontology (among notable exceptions is Germon et al., 1987), especially of vertebrates.

There was nothing in the least casual or chancy in the collection of North American fossils; rather, they resulted from a purposive campaign. In fact, it is a little surprising that the results were so meager for fossils in light of the effort expended. Much of the voluminous correspondence of Sloane, Petiver, Woodward, and others was devoted to creating and maintaining a network of collectors, not least in the New World.

A very good taste of the flavor of time and place can be had from Stearns' (1952:293–303) account of how the group cooked up a collector in cleric's clothing. The Bishop of London, in 1694, sought advice from Martin Lister in recommending a candidate for chaplain to the governor of Maryland. This eventuated in Edward Lhwyd's putting forward his assistant, Hugh Jones, whose specific qualification was that he would be a worthy successor to John Banister. Jones was groomed in natural history, run hastily through religious orders, and rushed off to Maryland. Besides Lister and Lhwyd, James Petiver, Samuel Doody, Jacob Bobart, and Tancred Robinson are known to have had specific roles in the care and feeding of Jones; Petiver quite literally—besides equipment, supplies, and literature, he sent Jones a cheshire cheese and English beer, plus medicine and medical advice (Stearns, 1952:297, 299, 303).

John Woodward (1696) provided "brief instructions" to geological collectors (see Eyles, 1971:403; Price, 1989:93, footnote 7). Petiver also prepared instructions, which were sent out with travellers and to correspondents. These were highly sophisticated, even to the point of recommending the stomach contents of sharks, and other great fish, as a source of "divers strange animals not easily to be met with elsewhere" (Stearns,

1952:363). As to fossils (his "formed Stones), Petiver instructed, "These must be got as intire as you can, the like to be observed in marbled Flints, Slates, or other Stones, that have the Impression of Plants, Fishes, Insects, or other Bodies in them; these are to be found in Quarries, Mines, Stone or Gravel Pitts, Caves, Cliffs, and Rocks, on the Sea shoar, or wherever the Earth is laid open" (Stearns, 1952:364).

Thus, these natural historians knew exactly what they wanted and devoted much thought, energy, and money toward getting it. Much of their massive correspondence concerns details of instructing, inducing, exhorting, even bribing others to collect (e.g., see MacGregor, 1995, on Sloane's correspondence and Stearns, 1952, on Petiver's).

SHARKS' TEETH.—Sharks' teeth are the quintessential enigmas of nature, whose charm has inspired wonder, and finally researches, more widely and continuously than perhaps any other fossil. It would scarcely be possible to overemphasize their importance in cutting-edge debate on the meaning, nature, and definition of fossils in the sixteenth and seventeenth centuries. As indicated earlier, Rudwick (1976) has done a masterful job in laying out the major features of the story as it unfolded in the pioneering works of Colonna, Scilla, Steno, and Hooke; these need not be retold, but some essential points may be emphasized.

First, "fossil" continued for many years to encompass almost any, usually natural, object "dug-up" from the earth, notably mineral specimens. "Figured stones" was a common term for what we now understand as fossils. Until there was general acknowledgment that objects resembling living animals or plants actually were remains of once-living things, there was no logical basis to require a distinction from other interesting things dug up.

Sharks' teeth, as glossopetrae or tongue-stones, were widely and deeply embedded in European pre-scientific culture, emanating especially from Malta, where the fossils are abundant and are conveniently intertwined with the religious and magical lore of St. Paul, serpents, and poison (for a sampling of this lore, see Zammit-Maempel, 1975, 1989, and Bassett, 1982).

From our present god-like heights of sophistication we have tended to dismiss the seeming wrongheaded reluctance to recognize sharks' teeth and other fossils for what they are as the ridiculous ignorance of benighted times; however, these gentlemen were no simpletons but rather the greatest minds of that or any other age. Even after presentation of the careful, logical arguments of Steno and Hooke, widely circulated in the Royal Society, that community of scholars did not rise as one in acceptance. Instead, the subject was hotly contested for some 30 years before being laid to rest pretty much by the early 1700s. Grew, Hooke, Lhwyd, Woodward, Ray, Lister, Newton, and Scheuchzer all weighed in on the issue (e.g., see Stokes, 1969). Some, including Hooke, Woodward, and Scheuchzer, were decisive in their support of organic origin. In this group only Lister was adamant in his opposition. His views have been characterized as ridiculous in hindsight, but his problem, in part, may have been that he knew too much. Lister knew mollusks as perhaps none other of the time, and demanded, but did not find, exact correspondence between fossil and living forms. He was no fool—witness his coming close to "inventing" geologic mapping (Lyons, 1944:99; Stearns, 1970:168). He might well be the Agassiz to Hooke's Darwin in this debate. Further, recognition of fossils as such created serious problems in the frame of reference of the time. From it followed almost inevitably the problem of extinction of forms without modern counterpart, and this was unacceptable in a perfectly economical universe, whether divine or natural. It was in relation to this problem that fossil and modern natural history specimens from far off places, such as America, held special appeal. Locally extinct organisms might well survive elsewhere.

With the possible exception of Lister, it might be observed that the practices of those who equivocated on the nature of fossils made sense only if they in fact accepted their organic origin. For example, Grew (1681:257) extrapolated (pretty successfully) on the size of shark (36 feet; ~11 m) from which large glossopetrae originated; Sloane's (1697) paper on ray teeth was based solidly on comparative methodology—his perfunctory allusion to God's wisdom seems all too much like covering his flank. One is tempted to suspect persistence of a certain measure of accommodation to authority through lip service while proceeding operationally on the basis of persuasive new insights.

Another fascinating aspect in which sharks' teeth illustrate how scientific discovery works is the fact that Steno, Scilla, Hooke, and Woodward were essentially coeval in their researches. Barring some more persuasive evidence of intellectual piracy than has thus far materialized, the interesting point is that this was an idea whose time had come. Hooke was a great and wide-ranging idea man, and there is no need to detract from his astounding originality. His geologic insights and priorities have at last been well presented (Drake, 1996). Nevertheless, he clearly had a tendency toward jealousy of priority—whatever the topic, he thought of it first (which contributed strongly to his irreparable schism with Newton). Even if Steno was aware of Hooke's and/or Scilla's ideas, he has to be accorded primacy because he developed the idea fully with step-by-step logical procedure, which has been brought out best by Scherz (1969, 1971). Woodward clashed with almost everyone, was a thoroughly unsympathetic character, and was accused of pirating Scilla's ideas, but he probably was not a plagiarist (Jahn, 1972:210) (useful and accessible insights into Woodward's activities and character may be found in Eyles, 1971, and Levine, 1977).

Another great truth illustrated by this history is that discoveries do not stay discovered; they must be tended like a garden. Scilla (1670) illustrated what turned out to be the first known specimen of a sharktoothed porpoise, family Squalodontidae, a nice piece of a mandible with three teeth. This historic specimen, preserved in the Woodward Collection at Cambridge, has since been the object of repeated attention in the paleontologi-

cal literature of the modern era. Although first formally described as a seal, and in one aberrant view regarded as a hippopotamus (Owen, 1840–1845:564–565, pl. 142: fig. 3), it has long since become securely and correctly embedded in the literature as a squalodont cetacean, the holotype of *Squalodon melitensis* (Blainville), where it has been alluded to and figured repeatedly (e.g., see McCoy, 1867:145; Kellogg, 1923:24; Gunther, 1937:433, unnumbered figure, p. 432; Fabiani 1949:26–29, figs. 9, 10; Rothausen, 1968:92). Then, in 1992, Gould (in Purcell and Gould, 1992:93–94, figs. 64, 65) misidentified the specimen as the jaw of a shark, invalid support for the valid interpretation of glossopetrae. Although as always we have a duty to correct objective mistakes, especially by contemporary and influential authorities (I wrote to Gould immediately upon discovering the error, 8 March 1993), the significant point is hardly that even the greatest living spokesperson for paleontology to the world at large is fallible, but that approach to truth is a fragile dynamic that requires continual vigilance. There may be some validity to Gould's (1996:110) claim that "persistent minor errors of pure ignorance are galling to perfectionistic professionals," but this has no bearing on the overriding requirement that each professional strive assiduously to get things right and never knowingly let even "minor errors" persist.

Finally, the history of sharks' teeth in relation to humans is a powerful cautionary tale against fashion in science. Fortunately, people in general have maintained a seemingly innate curiosity and interest in them throughout time. In professional paleontology, however, when I was a student some four decades ago at a prestigious university, only a naive beginner would risk being labelled childish, or worse, "amateurish," by betraying any interest in sharks' teeth (or dinosaurs). Now dinosaurs are the hottest topic in vertebrate paleontology, and even sharks are respectable subjects of investigation (Klimley and Ainley, 1996). Scientists are probably no more foolish as a group than the citizenry at large in lurching to extremes, but they may tend to appear so in retrospect because they put extreme views on record in emphatic terms. More reflective attention to the history of our science would undoubtedly tend to mitigate our most embarrassing emanations and perhaps damp down fadism. I hope that these few modest historical nuggets are enough to persuade readers that ancient specimens, many lost or mislaid, and the thinking and writing surrounding them are not mere quaint curiosities but are landmarks that can and should have meaning today.

Secord (1996:459) has made a forceful case for the value of history not merely as entertainment or nostalgia but as an active force in research, concluding:

> Rather, a bold enquiry into the past can uncover the basic structures and large-scale patterns of change which lie behind our current dilemmas. We have inherited not just our institutions and practices, but our problems: and these can only be understood as products of history. A new culture of natural history will flourish only if it is effectively rooted in—and draws upon—a critical understanding of the past.

**Acknowledgments**

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