AMMONITES: AMMON'S HORNS INTO CEPHALOPODS

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Ammonites, unlike the living pearly and paper nautili, have yet to be graced by the poetry of a Holmes[1] or a Pope[2] and are less widely known outside paleontological fields; however, their esthetics, abundance, widespread distribution, and the legends associated with these geologically useful extinct cephalopods have captured the literary attentions of Scott, Schiller, and Goethe.

Ammonites, or more recently ammonoids,[3] like many other long-known fossils, although not always understood as to their nature and origins, have been associated with necromancy, myths, legends, and history since Late Paleolithic times. Six Jurassic specimens from Solutrean III at Forneau du Diable, Bourdeilles, France have perforated centers and may have formed a necklace somewhat like one found in a Bronze Age locality near Gravesend in Kent, fashioned by joining naturally vented Cretaceous sponges.[4] A number of markings which appear to be glyphs of some sort follow the curve of the outer whorl of an ammonite from the French Magdalenian[5] and may have been used in magic rituals similar to those of the North American Blackfoot Indians. As ammonites seemed to resemble sleeping bison to these indians, they were called "iniskim" or buffalo stones and hence were the central objects in the sacred bundles used in the sympathetic magic for corralling bison.[6] As talismans, they occur in the pouches of Navajo shamans.[7] Jurassic ammonoids from the Himalayas are used as amulets throughout India and as fetish symbols in Hindu temples where they are:

> . . . regarded as the embodiment of the god Vishnu, and spouse of the basil plant. They are called "salagrams" or "salagrama" [after the ancient village]. A draught of the water in which one of the sacred ammonites has been steeped is supposed to wash away sin and secure temporal welfare.[8]

"Ammonite",[9] literally "stone of Ammon", was derived from the resemblance of the crenulated whorls of these fossils to the ram's horns sacred to the ancient Egyptian deity Amun, or to those worn by him on his ram-headed effigies or those of Zeus (Jupiter)-Ammon, his Greek and Roman amalgams.[10] The ". . . ites" suffix is a remnant of the ideas concerning the non-organic nature of fossils, added to the names of objects which were thought to only resemble living organisms or their parts and were not their actual remains.

To the ancient Egyptians, Amun[11] originally represented the dynamic force "air" or "wind", the universal breath of life which animated all things. From obscure beginnings in Thebes during the Old Kingdom, he achieved national prominence by association with the successful Theban dynasts, and by the Eighteenth Dynasty, universality, with all the attributes of the previous creator deities, when merged with solar Re as Amun-Re, "King of the Gods".[12] The best known of his many oracles is that at Oasis Siwa[13] in the Western Desert some 350 miles west-south-west of modern Cairo. Through contact with the Cyrenian Hellenes beginning in the sixth century B.C., Amun was merged with Zeus, and

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the Oracle of Zeus-Ammon became famous throughout the Greek world.[14] After that of Apollo at Delphi, Siwa and Dodona in Epirus were the leading authorities in Hellenic affairs for centuries. Siwa, however, was an Egyptian oracle for Greeks—the principal native augur being at Buto in the Delta.[15]

Demigods and heroes, kings and princes, all visited or consulted the oracle during its prominence.[16] First among these was Alexander the Great, who arrived at Siwa in 331 B.C. after a miraculous journey from the coast.[17] As pharaoh and "son of Ammon" he afterwards wore the sacred ram's horns tied to a fillet so that they appeared to grow from his hair. Diadochi coinage shows him thus; he became known to legend as "Alexander of the Two Horns."[18] In time these horns were associated with the divine attributes of royalty in Successor kingdoms and the Roman Empire.[19] By late Hellenistic times the fame of the "Horns of Ammon" ensured their association with the oddly crenulated curved fossils common in certain parts of the Mediterranean basin.

Pliny the Elder refers to them as:

> . . . 'Hammonis cornu' or 'horn of Ammon,' which is among the most sacred stones of Ethiopia, has a golden yellow colour and is shaped like a ram's horn. This stone is guaranteed to ensure without fail dreams that will come true.[20]

Pliny later treats precious stones which derive their names from animals, by color or likeness (Chapter 72). Although he was familiar with the argonaut, and presumably by reading Aristotle with the nautilus, in view of the decline of the Ionian ideas of temporal perspective by this time, it is unrealistic to expect an analogy with the ammonites. These remained *Cornu ammonis* until the end of the controversy over the organic nature of fossils.

Solinus, obviously referring to Pliny's description, first mentions the occurrence of ammonites at Siwa:

> . . . Between this Towne [Cyrene] and the Temple of *Ammon*, are fourehundred miles, harde by the Temple is a fountaine consecrated to the Sunne, which with the moisture of his water byndeth the ground, and hardneth ashes also into a clod, wherin (not without wonder) the place glittreth rounde about none otherwyse than if it were the greene fields. There is also gathered the stone called *Ammons horne*. For it is so warpped and crooked that it is shaped like a Rams horne. It is bright as gold. Beeing layde under a mannes head when he sleepeth, it is said to represent unto him heavenly dreams.[21]

Unfortunately the geology of the oasis does not support this association; all its outcrops are of Miocene or younger age. The nearest Cretaceous exposures, the youngest rocks in which ammonites occur, are 150 miles distant.[22] This indicates that despite the classical sources the name originated in a general context rather than through occurrences of the fossils at Siwa.

No meaningful additions to the classical knowledge of ammonites seem to have been made prior to the work of the sixteenth-century Renaissance naturalists. Where *Ammonis cornu*, or one of its variant names, occurs in the medieval lapidaries the entries are paraphrases of Pliny.[23] Camillo Leonardi's *The Mirror of Stones*, which in one sense represents a culmination of the lapidary tradition at the beginnings of the "geological" renaissance, contains a description that is strikingly Plinyesque:

> . . . *Hammonis*, is a Stone of a gold Colour, and is numbered among the most sacred Gems. It has the shape of a Ram's Horn, and is found in *Ethiopia*. If a man puts himself in a Posture of Contemplation, it gives the Mind a Representation of all divine Things.[24]

Agricola's *De Natura Fossilium*[25] well illustrates the effect of the Renaissance on the geological sciences. His mineralogy, based on the physical characters of "fossils",[26] is free of much of the magical and mythical properties and spurious information that characterizes the earlier lapidaries. Here *Ammonis cornu* from Marienburg is a mineral covered with golden *armatura*, hard and striated, which imitates a horn.[27] Agricola views these and other stones as the products of a lapidifying juice, although not necessarily organic in nature.[28]

The lavish use of woodcuts (which had been supplemented by the use of etchings after the middle of the fifteenth century) characterizes many of Agricola's works; there are some 300 in *De Re Metallica* alone. The use of illustrations for scientific description pervades the treatises of the sixteenth-century natural historians.[29] Thus the first illustrations (of varying quality) of many fossils, including ammonites, occur in Konrad Gesner's[30] celebrated mineralogical treatise *De Rerum Fossilium*. There is a curious mixture of the organic and inorganic in his rendering of ammonites. The *Cornu serpentis* of the fourteenth chapter are described as *Concheae marinae*, stones that imitate or resemble marine animals, along with a fossil fish, a crab ("*Pagarus lapideus*"), and heart urchins ("*Echini marini*") that had easily recognizable living analogues. Another ammonite is figured and discussed in the following chapter: stones which imitate serpents and insects. This evolute ammonite, whose coiling type would now be termed "serpenticone", without its wider body whorl and with earlier whorls of rather equal height, must have seemed a perfect petrified serpent to Gesner, and unlike the other conchs which somewhat resembled *Nautilus*. Gesner also describes and illustrates a cidaroid echinoderm as a serpent egg ("*ovum anguinum*"),[31] although such "eggs" were correctly identified by his contemporary Palissy.[32] Gesner treats living cephalopods in the fourth volume of *Historia Animalium*, including in his discussion information from the studies of the Frenchmen Guillaume Rondelet and Pierre Belon, whose ecological view of "poissons" includes these creatures.[33] Unfortunately they did not discuss fossil fish and seem to have hedged on the nature of the fossil invertebrates they did consider.

One of the seven treatises bound with Gesner's *De Rerum Fossilium* is the catalogue of the personal cabinet of Johann Kentmann,[34] who actually edited the volume. The effect of catalogues of this type and those of the museums that closely followed, nearly all of which included specimens of ammonites, was to popularize the study of lithology throughout Europe during the seventeenth century. Fossils could be catalogued and preserved with relative ease by the virtuosi, discussed and exchanged with their fellows, and used to impress their friends. Later the fame of ammonoids among the *naturphilosophen* was such that Goethe mentions them in his geological discourses and Schiller has his hero Tell view flowers, rare birds, and ammonites on his pastoral walks (Act. III, iii).

Many of the catalogues of museums include references to *ophites*[35] which were equated with *Cornu ammonis*. These occur in the literature as early as the fourth (?) century A.D. poem of "Orpheus" on gems in which the fossil becomes the vocal stone, the truthful *Sideritis* or *Ophites*, containing a soul, round and black, and:

> . . . Around its face, in many a mazy bend,
> Like wrinkles deep the graven furrows trend.[36]

The poem relates how the seer fasted and kept chaste for seven days, then washed the stone, clothed and set it in the shrine, giving it life through incantations. Hearing its first

stirrings, he cast the ophite down and it then gave truthful answers to all questions, after which it was again bathed and its spirit departed.

Ophites also are mentioned in the "snakestone" legends and the name was applied with equal liberality in the lapidaries to marbles, serpentines, diabases, and basalt porphyries (the latter called *tephrias*, the modern tephrite), whose spotted surfaces were so like the mottled skins of serpents.[37] The idea that *ophites* or *Cornu ammonis* were petrified serpents, perpetuated through British snakestone folklore, was beginning to be recorded in the sixteenth century: ". . . Stones figurid like serpentes wounde into circles found in the quarreis of stone about Cainsham [near Bristol]."[38] were noted by John Leland during his travels through Somersetshire. The legends surrounding this occurrence as related by William Camden, who viewed these fossils as: ". . . little miracles of sporting Nature . . . winded round like a serpent . . . But most of them want the head."[39] involve the conversion of a wood full of venomous serpents by St Kenya's prayers. Those of Whitby in Yorkshire have a similar explanation; snakes abounding near the cloister in the seventh century until they were decapitated and petrified by the efficacy of the prayers of St Hilda, the Saxon abbess.[40] Sir Walter Scott relates in *Marmion* (Canto Second, XIII):

> . . . How of a thousand snakes, each one
> Was changed into a coil of stone,
> When holy Hilda prayed . . .
> Themselves [the nuns] within their holy bound
> Their stony folds had often found.

To lend the story authenticity, heads were carved on some specimens which were then sold to the curious. One of these, a specimen of the Jurassic eoderoceratacean *Dactylioceras commune* (Sowerby), has been in the possession of the British Museum (Natural History) since about 1815.[41] This nefarious practice was not restricted to the English, for a similarly altered Jurassic psiloceratacean *Coroniceras rotiforme* Sowerby was acquired by the Vienna Natural History Museum in 1880.[42]

Fanciful tales of the origin of *Cornu ammonis* or ammonites as they were beginning to be referred to with equal frequency, were popular among the English countryfolk through the nineteenth century. James Parkinson was once shown a snakestone by the owner of an alehouse near Oxford who told him it was originally one of the fairies: ". . . once the inhabitants of these parts, who for their crimes were changed, first into snakes, and then into stones."[43] Another fossil represented their petrified night-caps (one of the cap-shaped gastropods?). Parkinson quotes another curious tale from Richard Carew's *Cornwall* in which:

> . . . the snakes, by their breathing about a hazell wand, doe make a stone ring of blew colour, in which there appeareth the yellow figure of a snake; and that beasts which are stung, being given of the water wherein this stone has been soked; will therethrough recover. There was such a one bestowed on me, and the giver avowed to have seen part of the stick sticking in it; but *Penes authorem sit fides*.[44]

The real nature of fossils continued to be under heated debate, especially among that famed circle of learned and ingenious men of the Royal Society of London in the late seventeenth and early eighteenth centuries. Martin Lister commenting on the organic view of fossils expressed in Steno's *Prodromus* in a letter to the Society states: ". . . these Cockle-like stones ever were, as they are at present, *Lapides sui generis*, and never any part

of an Animal."[45] To Robert Plot, who inclined toward the ideas of his friend Lister as to the production of fossils in place by a plastic virtue latent in the earth, rejecting both a diluvial origin and "animal molds", Oxfordshire *Cornu ammonis* or *Ophiomorphits* were: ". . . most probably formed by two *salts* shooting [crystallizing] different ways, which by thwarting one another make a *helical* figure . . .".[46] These inorganic views of fossils, or "formed" or "figured stones" (*lapides figurati*) as they were most popularly known, drew the caustic comments of the noted diluvialist John Woodward,[47] Professor of Physick at Gresham College, and the compelling arguments (especially to modern readers) of Robert Hooke[48] who accepted fossils as the petrified remains of past life and derided the ideas of a *vis plastica* and the like. Hooke described Portland ammonites ". . . of a prodigious bigness", discovered the sutures represented external boundaries of internal partitions, and concluded: ". . . that these Shells [from Keynsham] which are thus *spirallied* and separated with *Diaphragmes*, were some kind of *Nautili* . . ."[49] probably extinct, although they might yet be found in the limboes of oceanic depths or distant seas.[50] In this Hooke was alluding to the uncertainties of Edward Lhwyd[51] and John Ray, who while supporting modified organic views, knew of no analogues in European seas. Hooke's answer to this objection was detailed comparisons of the fossils with living externally shelled cephalopods before the Royal Society in 1689. Two plates of realistic three-dimensional figures of examples of each of the above were drawn by Hooke himself to convince his audience the ammonites had once been alive:

> . . . Anyone that will diligently and impartially examine both the Stones and Shells, and compare the one with the other, will, I can assure him, find greater reason to perswade him of the Truth of my position than any I have yet urged or can well produce in Words; no Perswasions being more prevalent than those which these dumb Witnesses do insinuate.[52]

Contemporary continental virtuosi held at least as wide a variety of ideas on the origin of *Cornu ammonis*. Johann Reiske[53] believed them to be inorganic. Karl Nicolaus Lang modified Lhwyd's spermatic ideas; he describes *Ammonites* as: ". . . coiled figured stones, convoluted after the manner of serpents, so that their circles do not have any point of inception."[54] Georg Wedel[55] and Georg Behrens embraced organic views somewhat like those of Hooke; Behrens supposing: ". . . the *Cornua Ammonis*, were once real which are now allow'd on all hands to be Stones of a particular Kind."[56] Behrens relates how the Gandersheim farmers used as witchbane:

> . . . a fossile shaped like a Ram's Horn call'd Drake [Dragon]-stone . . . for when the Cows lose their milk, or void Blood instead of it, they put these Stones into the Milk-pail, and by that means expect a due quantity of Milk from those Cows again.[57]

The researches of Behrens's contemporary Georg Rumpf on pearly nautilus, his "Nautilus Major", which he was able to observe first-hand in East Indian waters, contains the earliest modern descriptions of its conch and internal anatomy.[58] Although there are some inaccuracies in the discussion of the soft parts, the work was unsurpassed until Richard Owen published his detailed and beautifully illustrated treatise on *Nautilus* in the next century.[59] Rumpf's "*Cornu Ammonis*", considered by him a small analogue of the major nautilus, is actually the living *Spirula*.[60] Added to the comparisons of Hooke and Antoine de Jussieu,[61] Rumpf's studies ensured the acceptance of ammonites as fossil cephalopods by the close of the first half of the eighteenth century. There were of course dissenting conservatives, Voltaire being the most illustrious of these. Vigorously assailing

the naturalists who denied his orderly Newtonian world system, to him merely for the sake of a few shells, Voltaire opposed geologic and biologic change by disputing their identity:

> . . . As for the ammonites, known for ages as serpent stones, it was obvious to him that they were coiled snakes which had been petrified, or stones which had formed in such a shape.[62]

Although accepted as organic by most nautralists, the diluvial explanation of the occurrence of fossils prevailed until well into the nineteenth century, when the acceptance of biological and geological uniformity made this and other explanations untenable. The fundamentalist reaction to Darwin produced a general officer's defense of Scripture in which it was hoped that some of the 500-odd species of ammonites would prove to be: ". . . gigantic Planorbi of the primeval forests, they would speak volumes regarding the Deluge and the comparatively recent present garment of the earth . . .".[63]

During the eighteenth century, with the organic nature of ammonites becoming increasingly well-established, naturalists were giving greater attention to systematizing the potpourri of species which had by then been accumulated. Concepts of "species" varied considerably; estimates of the number of valid taxa varied from tens to hundreds, which resulted in a number of complaints of taxonomic over-refinement which have a curiously modern aspect. Elie Bertrand, after listing the number of species of the various authors (Scheuchzer's totalled 149), observes there seems to be almost an infinite variety. To reduce the confusion, he limits himself to three species based on ornamentation; smooth, striated, and tubercular.[64] Ideas as to which taxa were valid obviously depended upon which of the physical characters of the conch were emphasized. Although Linnaeus placed all of the vulgar *Cornu ammonis* in a single species, *Hammonites*, of the fossil genus *Helmintholithus*,[65] one which contained a myriad of other shelled molluscs and echinoderms, some 300 taxa existed by the late eighteenth century. In proposing the genus *Ammonites* in 1789 for *Cornu ammonis* with evolute whorls, Jean-Guillaume Bruguière[66] was formalizing common practice which also used "nautilus" or "nautilites" for the involute forms. Parkinson later suggested this usage omitted the so-called living ammonites (actually foraminifers) discovered in Italy by Jacob Beccari and Johann Bianch. (Janus Plancus) early in the eighteenth century. He thought *Ammonautilus* might be applied to these to indicate they shared the characters of both genera.[67]

The researches of Cuvier and Lamarck in the late eighteenth and early nineteenth centuries began modern cephalopod studies, briefly considered here to 1865, the time of the first major fractionalization of the genus *Ammonites*. Georges Baron Cuvier first used the term "Cephalopodes" at the ordinal level in 1798 to join the living forms, then including the foraminifers, in one higher taxon.[68] Ammonites and other fossils similar to *Nautilus* are discussed under that genus although their definite place in the order remained conjectural at that time.[69] Jean de Monet, Chevalier de Lamarck, considered by some the founder of modern conchology, included Bruguière's *Ammonites* among his eleven multiocular univalve "Mollusques Cephales" three years later.[70] By the end of the decade, Lamarck had rearranged these and additional taxa into seven families of polythalamous cephalopods, one of which was "Les Ammonées";[71] he had early distinguished and emphasized the sutural differences between ammonoids and nautiloids. Both he and Cuvier viewed ammonoids as internal shells analogous to *Spirula* and not to *Nautilus*, an idea later contested by von Buch.[72]

Additional genera were established periodically during the remainder of the first half of the nineteenth century. However, the next meaningful advance in the comprehension of cephalopod systematics was the recognition of foraminifers as separate biologic entities. This required the discovery of the presence or absence of a siphuncle in the shell, or the test, noted by Wilhelm de Haan and Alcide d'Orbigny in the 1820's (it was the latter who first used "Foraminifères"), and the unicellular nature of the soft parts, recognized by Felix Dujardin in 1835.[73] De Haan also continued the study of suture lines emphasized by Lamarck, proposing a third family, the "Goniatitae", for forms whose septal edges were simply undulated and angular.[74]

Perhaps the greatest contributions to the study of fossil cephalopods in the nineteenth century were those of Leopold von Buch,[75] published during the 1830's, which provided inspiration for generations of later workers. In these, von Buch emphasized the distinction between the siphuncular positions in nautiloids and ammonoids, established a definite sutural terminology which aided in separating the ammonoids into three "sections" based on sutural configuration, and further divided into fourteen families by conch shape and ornament—a separation he felt was gradational. Here are the beginnings of ideas that ammonoid phylogenies based on progressive complication of sutural patterns might be used in chronologies.[76] Von Buch's work along with the researches of Richard Owen, who gave the names "Dibranchiata" and "Tetrabranchiata" to the "naked" and "shelled" orders,[77] and those of François-Jules Pictet[78] provided the basic classification of cephalopods until the 1860's.

Monographic treatments of cephalopod faunas during the middle nineteenth century yielded a number of new genera, many derived from *Ammonites*, by then considered primarily a form genus. Yet even with all the systematic revisions, Owen, writing in 1860, refers to more than 500 species of the genus, a number he considers perfectly natural: ". . . The sections into which, for the sake of convenience, this extremely natural group has been broken up, are very ill-defined and have no pretension to be considered subgeneric."[79] When Eduard Suess proposed *Arcestes*, *Phylloceras*, and *Lytoceras*[80] for some of these subgenera, retaining *Ammonites* in a stricter sense, he used conch features such as body length and the nature of the aperture in addition to those stressed by von Buch. This seems to have initiated a large scale refinement, or splitting depending on one's taxonomic philosophy, that was also advocated by Suess's contemporary Alpheus Hyatt, a trend evident in the work of those they influenced later in the century (it would be interesting to trace their "phylogenies"). As a result of these studies, the concepts of many genera became increasingly more narrow and *Ammonites* was no exception. Although it eventually was suppressed for nomenclatural priority by the International Commission on Zoological Nomenclature in 1954,[81] the original nomen remains as a prefix in several suprageneric taxa and is still the common name for these fossils.

This brief survey of the history of study and development of ammonoid systematics to the beginning of the fractionalization of genus *Ammonites* in 1865 contains little material on the many nineteenth-century workers who made important contributions to the knowledge of ammonoids.[82] Taxonomic developments after the 1860's are so numerous, complex, and sometimes slightly bewildering that they, with all post-Linnaean systematics, easily form the subject of a separate paper. Pre- and contemporary Linnaean studies accomplished the important transition of ideas on the nature of ammonites, from the classical-medieval view of them as stones or minerals resembling the Horns of

Ammon, with their supposed prophetic powers, through the dragon and snakestone legends and inorganic ideas of *ammonites* as *lusus naturae* prevalent in the seventeenth century, to their acceptance as organic remains by the middle of the eighteenth century, and finally, toward the close of that century, the adoption of the modern restricted usage of the term "ammonite" for coiled, complex-sutured, fossil cephalopods.

NOTES

[1] Oliver Wendell Holmes' "Ship of Pearl" is well known:

This is the ship of pearl, which, poets feign,
Sails the unshadowed main—
The venturous bark that flings
On the sweet summer wind its purpled wings
In gulfs enchanted, where the siren sings,
And coral reefs lie bare,
Where the cold sea-maids rise to sun their
streaming hair . . .

The remaining four verses comprise an allegorical comparison of the successive chambers to the life stages of man, until both are ". . . wrecked . . ." and ". . . free . . ." leaving the ". . . outgrown shell by life's unresting sea." "The Chambered Nautilus", *The Autocrat of the Breakfast Table. Every Man His Own Boswell . . . The Complete Writings of . . . Holmes . . .* (New York: Houghton Mifflin Co., 1892), **I**: 97–98.

[2] The "Ship of Paper" is less familiar:

. . . Thus then to Man the views of Nature spake—
Go, from the creatures thy instructions take . . .
Learn of the little nautilus to sail,
Spread the thin oar, and catch the driving gale . . .

Pope. Essay on Man. Ed. by A. H. Thompson (Cambridge: at the University Press, 1913), p. 30. Alexander Pope (1688–1744) wrote *Essay* as a versified philosophy treating uneven distribution of happiness on earth. These couplets refer to nature as the only guide of man to deity. The rowing-sailing qualities of the argonaut were derived from Oppian's *Halieutica*, written by the zoologist-poet in the late second century A.D. *Oppian . . .* With an English Translation by A. W. Mair. (London: William Heinemann Ltd, 1928), **I**: 340ff.

Both *Nautilus* and *Argonauta*, the only living externally shelled cephalopods (females of the latter genus secrete temporary shells as egg cases), were known to Aristotle (*Historia Animalium*, Book 4, Chapter 1).

[3] These cephalopods comprise the modern subclass Ammonoidea Zittel, 1884, as used in the *Treatise on Invertebrate Paleontology. Part K. Mollusca 3 . . .* Directed and Edited by Raymond C. Moore. (New York: The Geological Society of America and the University of Kansas Press, 1964), K12, and thus in a strict nomenclatural sense the common name should now be "ammonoid". However, the name "ammonite" long antedates "ammonoid", which is an outgrowth of the recent tremendous elaboration of the classification of the group. Use of "ammonoid" implies that "ammonite" is restricted to a more limited group, the members of the order Ammonitida Zittel, 1884. As a collective term for all ammonoids, "ammonite" certainly has priority, and at this level—at which the term originally was used—the modern distinction between ammonoid and ammonite is often inconsequential. "Dinosaur" has a somewhat comparable history, with certain differences (Joseph T. Gregory, written communication, June 1967).

[4] Kenneth Oakley, 1965, "Folklore of Fossils, Part I", *Antiquity. A Quarterly Review of Archaeology* **39**: pl. IIc,d. For the collecting activities of the "paleo"-paleontologists, see Raymond Furon's "The Dawn of Science: Prehistoric Beginnings", *History of Science. Ancient and Medieval Science From the Beginnings to 1450.* Edited by René Taton. Translated by A. J. Pomerans. (New York: Basic Books, Inc., 1963), pp. 6–7.

[5] As described in A. Ragout, 1934, "La Grotte de l'Ammonite. Gisement Magdalénien", *Revue Anthropologique* **44**: 139 (fig. 2: 21). The nature of the line drawing makes interpretation difficult.

[6] Thomas F. Kehoe, 1965, "Buffalo Stones: 'An Addendum to the Folklore of Fossils'", *Antiquity . . .* **39**: 212–213.

[7] John B. Reeside oral communication to Harry S. Ladd reproduced in Ladd's "Introduction", *Treatise on Marine Ecology and Paleoecology. Part 2. Paleoecology.* (New York: The Geological Society of America, 1957), Memoir **67** (2): 5.

[8] Oakley, *op. cit.*, p. 15.

[9] The many synonyms include *Cornu ammonis, Ammonis cornu, Hammonis cornua, Cornua hammonis, Ammonis lapis, Ammonitae, Ceratoides, Chrysalites, Chrysammonites, Ophites, Ophiomorphites, Ophioides, Serpens lapideus, Cornu lapideum, Cornu serpentis, Lapis serpentis,* snake stone, serpent stone, serpentine stone, *Corne d'Ammon, Corne de belier, Beaumepots, Drachenstein, Zieherhorn, Schnekenstein, Scheerhorn, Steinhorn,* and *Zaglik* among others. *Hammites* or *Ammites,* and unfortunately *Ammonites,* refer to oolitic or pisolitic rocks; *Conchae anomiae* were fossil brachiopods. The terms *Ammodite, Ammodites,* or *Ammodytes* in the classical and medieval zoology texts refer to vipers. This list of ammonite synonyms is derived primarily from Johann Jacob Scheuchzer's *Sciagraphia Lithologica Curiosa; seu: Lapidum Figuratorum Nomenclatur* . . . (Gedani: typis Thomae Johannis Schreiberi . . . 1740) and Elie Bertrand's *Dictionnaire Universel des Fossiles* . . . (A La Haye: Chez Pierre Gosse Junior, et Daniel Pinet, 1763). The half-title is *Dictionnaire Oryctologique Universel.* Another 1763 edition of the *Dictionnaire* [2v. in 1] was published at Avignon by Louis Chambeau.

[10] *Part L. Mollusca 4* (Ammonoidea) of the *Treatise* . . . (1957) contains little in the way of a historical review of classification that characterizes some of the later volumes. Other than entries in a few oryctological dictionaries and nomenclators, and isolated short monographic references, the only major work treating origins, usages and legends concerning the ammonites is Johann Reiske's "Exercitatio Historico-Physica de Cornu Hammonis, quod Veteres vocârunt, Agri Brunshusani et Gandersheimensis Lapide, quem vulgo Drafenstein nominant . . ." which appeared as an appendix in *Miscellanea Curiosa Sive Ephemeridum Medico-Physicarum Germanicarum Academiae Imperialis Leopoldinae Naturae Curiosorum Decuriae II. Annus Septimus, Anni* [1688] . . . (Norimbergae: Sumptibus Wolfgangi Mauritii Endteri, 1689), pp. 163–227. Reiske (1641–1701), naturalist and Rector of Gymnasia at Weimar, Lüneburg, and Wolfenbüttel during the last quarter of the seventeenth century, also wrote a somewhat better-known treatise on the Lüneburg glossopetrae. His wide interests are described in the *Allgemeine Deutsche Biographie* . . . (Leipzig: Verlag von Dunder and Humblot, 1889), pp. 128–129.

[11] Amun, Amen, Amon, or the classic form Ammon; from the hieroglyph [𓇋𓍿]. The name is translated as "hidden" or "concealed". Amon or Ammon also appears as a Biblical nomen and was the name of an ancient Semitic kingdom, whose capital Rabbath-Ammon, later Philadelphia, is the site of modern Ammān, capital of the Hashemite Kingdom of Jordan.

[12] The rise of this figure has been traced by many Egyptologists; see the classic works of James Henry Breasted and John A. Wilson, 1951, *The Burden of Egypt. An Interpretation of Ancient Egyptian Culture.* (Chicago: The University of Chicago Press), pp. 130ff.

A god of many forms, Amun was usually represented as an erect, mature man, sometimes with the features of the reigning pharaoh and the long pharaonic goatee, wearing a golden cap topped by two tall plumes often with the solar disc at their base. James Bonwick, 1956, *Egyptian Belief and Modern Thought.* (Indian Hills, Colorado: The Falcon's Wing Press), p. 123.

Although Amun did not attain the popularity of Osiris, he was well-loved by the people. Breasted mentions his guise as "vizier of the poor" which evoked the popular "If Amon spare my life" resembling the Moslem "Inshallah". Breasted, 1964, *A History of Egypt From the Earliest Times to the Persian Conquest.* (New York: Bantam Books, Inc.), p. 205.

[13] Siwa or Siwah was known to the Egyptians as Seket-am (Land of Palms), as Ammonium to the Hellenes, and is the Santarîah of the Berbers prior to the sixteenth century. Siwa is actually a group of oases some 35 miles long. Temple and oracle were built on Aghurmi, one of the two limestone acropoli, Siwa town on the second.

[14] As indicated by Aristophanes in his comedy, *The Birds* (lines 618, 619, 716). Oasis and oracle have been the subjects of a number of interesting books; most recent of these is Ahmed Fakhry, 1944, *Siwa Oasis. Its History and Antiquities.* (Cairo: Government Press, Bulaq). Fakhry, professor emeritus at the University of Cairo, has written a number of papers on the Western Desert and is renowed for his researches on the Gîza Pyramids. See also [Gustav F. C.] Parthey, 1863, "Das Orakel und die Oase des Ammon", *Abhandlungen der Königlichen Akademie der Wissenchaften zu Berlin. Aus dem Jahre 1862* [Philologische und historische Abhandlungen], pp. 113–194; C. Dalrymple Belgrave, 1923, *Siwa. The Oasis of Jupiter Ammon.* (London: John Lane, The Bodley Head Ltd); and, Oric Bates, 1914, *The Eastern Libyans. An Essay.* (London: Macmillan and Co., Ltd), pp. 187ff.

Many are the miraculous tales of the origin of the oracle and the nearby *Fons Solis* from such heralds as Herodotus, Solinus, Servius, and Diodorus Siculus. The earliest records from Siwa are from the sixth-century Twenty-sixth Dynasty, by which time the parent Theban oracle at Karnak had declined to such a degree that it possessed neither major religious nor political significance (Breasted, *op. cit.*, p. 478).

[15] Fakhry, *op. cit.*, p. 44.

[16] A list of these reads like a classical "Who's-Who" including Hercules, Perseus, Semiramis, Croesus, Pindar, Lysander, Pausanias, and Hannibal (Parthey, *op. cit.*, pp. 156ff. and Fakhry, *op. cit.*, pp. 29–45).

[17] Described by Flavius Arrianus, *Anabasis. III*: 2ff.

[18] For a discussion of the varied legends, including the Arabic *Iskander dhulcarnein*, see Harold Lamb's historical novel *Alexander of Macedon*. (New York: Bantam Books, Inc., 1955), pp. 283–284.

[19] H[enry] B. Walters, 1926, *Catalogue of the Engraved Gems and Cameos Greek Etruscan and Roman in the British Museum*. (London: Oxford University Press), pp. 135, 341. See also Charles W. King, 1866, *The Handbook of Engraved Gems*. (London: Bell & Daldy), p. 366, fig. 38. Horns of this sort continued to turn up in various associations and locations. The Sassanid cavalry of Shapur II, who opposed the armies of the Emperor Julian in the fourth century A.D., bore them on their helms (King, *op. cit.*, p. 367). One tradition traces them from the Kushite Twenty-fifth Dynasty, through the Nubian Coptic kings, to the paraphernalia of the sixteenth- and seventeenth-century Fung Empire centered at Sennar on the Blue Nile. A horn of the goat with whose milk the Cretan nymph Amalthea nursed Zeus, later broken by him, became the legendary *Cornu copiae*, and is recalled by genus *Amaltheus* de Montfort, 1808. Thomas Bulfinch, 1934, . . . *Mythology. The Age of Fable* . . . (New York: Random House, Inc.), p. 146. Many generic names bear the suffix "ceras" from the Greek root for "horn".

Other ammonoid generic names also have Hellenic etymologies; *Arietites* Waagen, 1869 is derived from Aries, the Ram of the Zodiac. *Hoplites* Neumayr, 1875 honors the formidable Greek heavy infantry. The brazen luster of pyritized ammonoids gives them an armored appearance, termed *armatura* by the medieval miners, a name also given to fault slickensides as recorded by Agricola.

[20] Gaius Plinius Secundus (*ca.* 77 A.D.), . . . *Natural History*. With an English translation . . . by D. E. Eichholz . . . (Cambridge, Massachusetts: Harvard University Press, 1962), **10**: 301 (Book 37, Chapter 60). It seems Pliny is having his readers on here, as the next sentences refer to the sybillic ability of hyena stones when placed under a man's tongue ". . . if we are foolish enough to believe such a thing." He is more discerning than he is sometimes made to appear; see his comments on the origins and properties of glossopetrae in Book 37, Chapter 59.

[21] Gaius Julius Solinus, *The Excellent and Pleasant Worke Collectanea Rerum Memorabilium* . . . *Translatde from the Latin* (*1587*) *by Arthur Golding*. (Gainsville, Florida: Scholars' Facsimiles & Reprints, 1955), Chapter 39: "Of Affrick . . ." Solinus continues: ". . . Also there is a Trée called *Metops* out of which floweth a clammy gumme, which of the place it commeth fro, we call Ammoniack" (Golding, *ibid.*).

Pliny (Book 31, Chapter 39) mentions *sal-hammoniacum* near the oracle, where its bulk increases with the waxing moon. See Herbert Clark and Lou Henry Hoover, 1950, *Georgius Agricola. De Re Metallica* . . . (New York: Dover Publications, Inc.), p. 560, note 8, for the relation of these to ammonium chloride.

The *De Natura Animalium* of Polyhistor's contemporary Claudius Aelianus contains only the living cephalopods.

[22] In the Bahria [Baharia] Oasis. They also crop out near the Farafra Oasis further south, and just west of the Gîza Pyramids. Rushdi Said, 1962, *The Geology of Egypt*. (Amsterdam-New York: Elsevier Publishing Company), fig. 2, facing p. 24. The Carte Géologique Internationale de L'Afrique (Échelle 1:5.000.000, 1948–1952) shows only Miocene rocks on the Libyan Plateau between Siwa and Cyrene (now Shahhāt). There are two smallish Cretaceous exposures shown some 50 miles southwest of Cyrene.

[23] George Sarton, 1961, in his *Appreciation of Ancient and Medieval Science During the Renaissance* (*1450 = 1600*). (New York: A.S. Barnes & Co., Inc.), p. 78, views the *Natural History* as ". . . one of the most influential books ever published. It was the favorite scientific encyclopedia of medieval times."

[24] *The Mirror of Stones: In Which the Nature, Generation, Properties, Virtues and various Species of*

more than 200 different Jewels, precious and rare Stones, are distinctly described. Also certain and infallible Rules to know the Good from the Bad, how to prove their Genuineness, and to distinguish the Real from Counterfeits. Extracted from the Works of Aristotle, Pliny, Isiodorus, Dionysius Alexandrinus, Albertus Magnus, etc. . . . By Camillus Leonardus, M.D. A Treatise of infinite Use, not only to Jewellers, Lapidaries, and Merchants who trade in them, but to the Nobility and Gentry, who purchase them either for Curiosity, Use, or Ornament. Dedicated by the Author to Caesar Borgia. Now first Translated into English. [Anonymous] (London: Printed for J. Freeman in Fleet-street, 1750), p. 110. The third book of the first edition of 1502 is omitted in this translation. The 1610 edition is *Speculum Lapidum . . . Cui Accessit Sympathia Septem Metallorum ac septum selectorum Lapidum ad Planetas.* (Parisiis: Apud Carolum Senestre et Davidem Gilliu).

Leonardi, physician of Pisaro, consulted some 27 of the most famous classical and medieval lapidaries. He treats some 280 stones alphabetically in the traditional fashion and considers them products of celestial forces after Aristotle. Like the earlier lapidaries, *The Mirror* is filled with neocromantic and medical powers and moral lessons to be found in the minerals.

Some of the ideas and statements derived from Arabic sources in this popular little volume were anathema to the Church and eventually earned it a place in the *Index*. See Frank Dawson Adams, 1954, *The Birth and Development of the Geological Sciences.* (New York: Dover Publications, Inc.), pp. 155–159, for comments on Leonardi and a discussion of the whole of medieval mineralogy (Adams, *ibid.*, pp. 137ff.).

[25] The renowned Georg Bauer (1494–1555), physician, mineralogist, geologist, and mining engineer in Saxony, is perhaps the best example of the merging of the humanist-scholar and artisan traditions during the sixteenth century. *De Natura Fossilium* was published in 1546 in a folio volume that includes four of Agricola's earlier works as *De Ortu et Causis Subterraneorum* . . . It has been translated by Mark C. and Jean A. Bandy as *De Natura Fossilium. (Textbook of Mineralogy)* . . . (New York: The Geological Society of America, Special Paper *63*, 1955). Short biographies of Agricola may be found in the above, Sarton (*op. cit.*, pp. 122–126), and Hoover and Hoover (*op. cit.*, pp. v–xi); see also Ernst Darmstaedter, 1926, ". . . Georg Agricola . . . Leben und Werk," *Beiträge zur Geschichte und Literatur der Naturwissenschaften und Medizin* . . ., Heft I (München).

[26] "Fossil" as used by Agricola and other sixteenth-century mineralogists referred to any object dug from the earth; many of which were actually minerals or rocks and not fossils as the term is presently applied to the remains or traces of prehistoric life. The long debate concerning the organic nature of fossils is well known. From the time of Leonardo learned men supported both sides of the question which was not resolved until the middle eighteenth century. Many of the varied views held during the controversy are divertingly recounted in the annotations of Melvin E. Jahn and Daniel J. Woolf's masterful unravelling of the Beringer legend, *The Lying Stones of Dr Johann Bartholomew Adam Beringer being his Lithographiae Wirceburgensis.* (Berkeley: University of California Press, 1963).

[27] Bandy and Bandy, *op. cit.*, pp. 98–99. The fifth book discusses "stones" but actually includes objects now considered minerals, rocks and fossils. The discussion of *ammonites* in the succeeding sentences does not refer to ammonoids, but to oolitic or pisolitic rock (see note 9):

> . . . formed from sand in such a manner that it has the appearance of fish roe and inside it sometimes has the same form and even the same color and texture. (Bandy and Bandy, *ibid.*, p. 99.)

[28] Jahn and Woolf (*op. cit.*, p. 184, note 1) discuss Agricola's ideas of the *succus lapidescens* and trace its later history.

[29] Sarton emphasises their importance for non-Latin readers in *Six Wings. Men of Science in the Renaissance* . . . (Bloomington: Indiana University Press, 1957), p. 155. See the discussion by Paul Delaunay under "Art and Zoology", emphasizing the contributions of Dürer and da Vinci and those that followed who illustrated the naturalists' works, in *History of Science. The Beginnings of Modern Science. From 1450 to 1800.* Edited . . . by René Taton. Translated by A. J. Pomerans . . . (New York: Basic Books, Inc., 1964), pp. 154–156. Another view of the importance of art in these times is developed by Giorgio de Santillana's "The Role of Art in the Scientific Renaissance", *Critical Problems in the History of Science.* Edited by Marshall Clagett. (Madison: University of Wisconsin Press, 1959), pp. 33–65.

[30] Konrad (Conrad, Conradus) Gesner [Gesnerus] (1516–1565), physician and Professor of Philosophy at Zürich, another of the humanist-scholars, whom Marie Boas Hall calls ". . . almost a universal scholar . . ." and Sarton terms ". . . one of the giants of the scientific Renaissance", was

primarily a botanist, but is best known for his momentous zoological compilation *Historia Animalium*, four volumes of which were published in Zürich during 1551–1558 and the fifth, posthumously, in 1587. The encyclopedist traditions were continued by the indefatigable Gesner, called *Plinius germanicus*, who, together with the noted Ulisse Aldrovandi (1522–1605) provided a polyhistor of natural history, albeit somewhat fanciful, from Aristotle to their time. Their volumes are particularly valued for their observations outside the classical and medieval texts. Willy Ley, paleontologist and rocketeer, wrote a short biography ". . . Konrad Gesner, Leben und Werk . . ." *Beiträge zur Geschichte und Literatur der Naturwissenschaften und Medizin* . . . Heft 15/16 (München, 1929). See also Sarton, *Appreciation*, p. 106, and Henry Morley, 1961, "Conrad Gesner", *Toward Modern Science. Studies in Renaissance Science*. Edited by Robert M. Paltner (New York: The Noonday Press), *II*: 90–114.

[31] Conradi Gesneri, 1565, *De Rerum Fossilium, Lapidum et Gemmarum maximè, figuris & similitudinibus Liber: non solum Medicis, sed omnibus rerum Naturae ac Philogiae studiosis, utilis & iucundus-futurus*. (Tiguri: [Apud Gesnerum]), p. 169 verso. *De Rerum Fossilium* is the last of the eight works on mineralogy bound as *De Omni Rerum Fossilium Genere, Gemmis, Lapidibus, Metallis, et Huiusmodi* . . . (Tiguri: 1565–1566). The fossil rendered on page 61 in the chapter speculating on brontiae and cerauniae may also be a sea urchin. The ammonites in question are illustrated on page 164 and page 168 verso, respectively. The figure on page 165 may be a nautiloid or a large planispiral gastropod. Nummulites from the Paris Basin are first described here; foraminifers were considered minute cephalopods until the early nineteenth century.

[32] For Palissy's (1510?–1590) organic view of fossils see Aurèle La Rocque's excellent annotated translation of the *Admirable Discourses* . . . [1580] (Urbana: University of Illinois Press, 1957), especially his introduction.

[33] The . . . *Libri De Piscibus Marinis, in quibus verae Piscium effigies expressae sunt* . . . [2v. in 1] (Lugduni: Apud Matthiam Bonhomme, 1554–1555) of Guillaume Rondelet (1507–1566), professor of anatomy at Montpellier, includes excellent naturalistic illustrations of squids, octopi, and the argonaut, and one of the earliest figures of a dissected invertebrate, a sea urchin (Rondelet, *ibid.*, p. 578). His contemporary Pierre (Petrus) Belon [Bellonius] (1517–1564), botanist and zoologist, who worked with the noted Valerius Cordus (who also taught Gesner), and travelled extensively in the service of Francis I, published a number of "ichthyological" and ornithological works between 1551 and 1557 containing at times equally fine figures. . . . *De aquatilibus, Libri duo, cum eiconibus ad vivam ipsorum effigiem, quoad eius fieri potuit, expressis*. (Parisiis: apud C[arolum]. Stephanum, 1553), p. 381 [not seen, there is also a 1552 edition printed by Stephan] contains a description and illustration of the conch of *Nautilus*, first illustrated by Belon in *L'histoire naturelle des estranges poissons marins, avec la vraie peincture & description du Daulphin, & de plusieurs autres de son espece, observee par Pierre Belon du Mans* . . . (Paris: De l'imprimerie de R. Chaudiere, 1551) [not seen].

Sarton (*op. cit.*, pp. 55–60) emphasizes the originality of Rondelet and Belon's observations, lists their works, and gives short biographies. Their work much advanced the natural history of these animals, even though their comprehension of order within the groups does not equal Aldrovandi's. In Italy, Hippolito Salviani (1514–1572) was studying Mediterranean and Adriatic fish and published *Aquatilium Animalium Historiae* in 1554. See Eugene W. Gudger, 1934, "The five great naturalists of the sixteenth century: Belon, Rondelet, Salviani, Gesner and Aldrovandi: a chapter in the history of ichthyology", *Isis* **22**: 21–40. For additional details of their contributions see Paul Delaunay, 1962, *La zoologie au seizième siècle*. (Paris: Hermann) and Georges Petit and Jean Théodoridès, 1962, *Histoire de la zoologie des origines a Linné*. (Paris: Hermann), pp. 253–275.

Naturalism in the illustration of living cephalopods had appeared as early as the work of Pier Candido (Petrus Candidus) Decembrio [Decembrius] (1399–1477), whose figure of the common squid *Loligo* published in 1470 is shown in Alistair C. Crombie, 1959, *Medieval and Early Modern Science. Volume I. Science in the Middle Ages: V–XIII Centuries*. (New York: Doubleday & Company, Inc.), pl. XVIII.

[34] Johann Kentmann (1518–1574), physician of Torgau, was author of two titles in Gesner's volume; *Nomenclaturae Rerum Fossilium, que in Misnia praecipue, et in aliis quoque regionibus inueniuntur* contains the descriptions of some 1,600 specimens in his cabinet (Jahn and Woolf, *op. cit.*, pp. 166–167).

[35] *Ophis*, the Greek root for serpent or snake, suggests an association with the ancient Egyptian sacred festival of Opet held during the Nile flood when the image of Amun traveled upstream from

Karnak for a month's residence at Luxor. Snakes were kept as domestic and temple divinities, the *uraeus* was sacred to Amun, and many of the cosmogonies included a primeval serpent.

The serpent entwined about the staff of Asclepius, Hellenic god of medicine, became equally famous in the Roman version of the cult. It is, however, apparently not the triplet of those on the caduceus, the winged staff originally Hermes' wand. See C[ároly] Kerényi, 1959, *Asklepios. Archetypal Image of the Physicians Existence*. Translated from the German by Ralph Manheim. (New York: Pantheon Books Inc.). Serpents later became one of the four symbols of the hidden divine wisdom of the Ophites, a Gnostic sect popular in the later Roman Empire, to whom true knowledge of divine things was involved in externals, both Pagan and Christian. See C. W. King, 1887, *The Gnostics and Their Remains, Ancient and Medieval*. (London: D. Nutt).

Early Greek legends also show the fascination, sometimes morbid, that snakes and "dragons" held for man. Edward Topsell, 1608, *The Historie of Serpents, Or, The second Booke of living Creatures* . . . (London: Printed by William Jaggard), a collection of the writings of Gesner and other naturalists, refers to: ". . . Ophion, a companion of Cadmus, and a builder of Thebes, who was said to be made by Pallas of a Dragons tooth" (Topsell, *ibid.*, p. 607). Similarly men born of snakes were "Ophiogenes" and the Spartans, who were supposed to have once eaten serpents during a famine, were called "Ophiodeiroi". In the seventeenth century ammonites were termed *ophites, ophoides*, and *ophiomorphites*.

[36] The exact date of the poem's composition is unknown. It was first quoted in the twelfth century and is given in its entirety by C. W. King, 1865, in *The Natural History, Ancient and Modern, of Precious Stones and Gems, and of the Precious Metals*. (London: Bell and Daldy), pp. 375–396. The passage quoted here is from page 385.

[37] Pliny describes these "marbles" in Book 36, Chapter 11. They were all thought to relieve headaches and snakebites, the *tephrias* being a particular specific for the latter.

[38] *The Itinerary of John Leland in or about the years 1535–1543. Parts IX, X, and XI* . . . [Volume 5 of *Leland's Itinerary in England and Wales* . . .], edited by Lucy Toulmin Smith. (London: G[eorge]. Bell and Sons, Ltd, 1910), p. 103. Leland (1506?–1552) King's Antiquary and Keeper of the Libraries of Henry VIII, who, with Nicholas Udall, wrote verses and ditties for the coronation of Anne Boleyn, and an ode on the occasion of Prince Edward's birth (Smith, *The Itinerary, Parts I, II, and III* [Vol. 1]: ix, x), traveled through the kingdom searching the libraries for ancient texts and compiling antiquities. The results of his search, containing observations on the natural history of the precincts through which he passed, were presented as a New Year's gift to Henry in 1546 and published with "declaracyons enlarged" by John Bale in 1549. This work, a veritable mine of information, inspired many succeeding antiquaries; both William Camden and Robert Plot are his debtors. See [William Huddesford and Thomas Warton's] *The Lives of those eminent Antiquaries John Leland, Thomas Hearne, and Anthony à Wood; With An authentick Account of their respective Writings and Publications, From Original Papers . . . In Two Volumes*. (Oxford: Printed at the Clarendon Press, For J. and J. Fletcher, in the Turl, and Joseph Pote, at Eton College, 1772) and H. B. Walter, 1934, *The English Antiquaries of the Sixteenth, Seventeenth and Eighteenth Centuries*. (London: Printed and Published by Edward Walters at Primrose Hill); the latter also contains short sketches of Camden and Plot in addition to notes on Leland.

[39] *Camden's Britannia, newly translated into English* . . . Published by Edmund Gibson . . . (London: Printed by F. Collins, for A. Swalle at the Unicorn at the West-end of St Paul's Churchyard . . ., 1695), p. 72. Bishop Gibson's edition contains numerous additions to the original text, many by Edward Lhwyd. It was first published as *Britannia. Siue florentissimorum regnorum, Angliae, Scotiae, Hiberniae, et Insularum adiacentium ex intima antiquitate Chorographica descriptio* . . . (Londini: Per Radulphum Newbery, 1586) by William Camden (1551–1623), the celebrated Elizabethan historian and antiquary, whose circle of friends included Archbishop James Ussher. The 1610 translation of the seventh Latin edition by Philemon Holland was not available to me. The passages describing the Keynsham and Whitby legends from this edition are quoted by John Challinor, 1953, "The Early Progress of British Geology.—I. From Leland to Woodward, 1538–1728", *Annals of Science* **9**: 126. Camden also notes that ". . . a great many *Ophites*, or stones roll'd up like serpents." occur near the village of Stretton in Stow, Lincolnshire (Gibson, *op. cit.*, p. 479).

The St Kenya legend is also preserved in a note to *The Natural History and Antiquities of Selbourne. By the Rev. Gilbert White, M.A.* . . . With notes by E. T. Bennet . . . and Others. (London: Printed for J. and A. Arch . . ., 1837), p. 13, note 3.

[40] See Oakley (*op. cit.*, pp. 13–14) for another discussion of these legends.

[41] It is figured in Wilfrid N. Edwards, 1931, *Guide to an Exhibition Illustrating the Early History of Palaeontology*. Special Guide No. 8. (London: Printed by Order of the Trustees of the British Museum), p. 16, fig. 4, and is also shown by Oakley (*op. cit.*, pl. IIa).

[42] As illustrated in Friedrich Bachmayer, 1958, "Ammoniten—die sonderbarsten Bewohner der vorzeitlichen Meere!" *Veroffentlichungen Naturhistorischen Museum Wien. Neue Folge* **1**: 17.

[43] James Parkinson, 1804, *Organic Remains of a Former World. An Examination of the Mineralized Remains of the Vegetables and Animals of the Antediluvian World; generally termed Extraneous Fossils.* (London: Printed by Whittingham and Rowland, Goswell Street; and Published by Sherwood, Neely, and Jones, Paternoster-Row . . .), **1**: 4. The second and third volumes of this excellent popular work were issued by a number of London publishers in 1808 and 1811, respectively. The first volume of a second edition was published in 1811, printed by "C. Wittingham" for the same houses.

[44] Parkinson, *ibid.*, **3**: 134. Richard Carew (1555–1620), antiquary, High Sheriff of Cornwall and friend of William Camden, dedicated his survey to Sir Walter Raleigh, then Lieutenant General of Cornwall. See Frank E. Halliday, 1953, *Richard Carew of Antony. The Survey of Cornwall* . . . (London: Andrew Melrose Ltd).

[45] Martin Lister, "A Letter . . . confirming the Observation in N° 74. about Musk sented Insects; adding Some Notes . . . and on that of M. Steno concerning Petrify'd shells", *Philosophical Transactions . . . Vol. VI. For the Year 1671.* [No. 76], p. 2282. Lister (1638–1711) was House Physician to Queen Anne and published a number of important conchological works; a list of these and details of his ideas on fossils are to be found in Jahn and Woolf (*op. cit.*, pp. 192–194).

[46] R[obert] P[lot], 1677, *The Natural History of Oxford-Shire, Being an Essay toward the Natural History of England.* (Oxford: Printed at the Theater in Oxford and are to be had there . . .), p. 123. Plot (1640–1696), an intimate of Samuel Pepys and John Evelyn, was first Keeper of the Ashmolean Museum, also Professor of Chemistry at Oxford, Secretary of the Royal Society and later Mowbray Herald Extraordinary. Plot's views are developed in detail and related to those of his contemporaries by Jahn and Woolf (*ibid.*, pp. 170–171).

[47] See Jahn and Woolf's (*ibid.*, pp. 176–178) comments on Woodward's (1661–1727) ideas of fossil origin and concepts of stratification. His ideas were enthusiastically supported on the continent by the celebrated Johann Jacob Scheuchzer of Zürich (1672–1733) who translated many of Woodward's works, being converted by them from his original view of fossils as *lusus naturae*. Scheuchzer enjoys a greater fame than Woodward, principally due to the unfortunate *Homo diluvii testis* episode (Jahn and Woolf, *ibid.*, pp. 173–176).

[48] The eminent Hooke (1635–1703) was first Curator of Experiments to the Royal Society and sometime Professor of Geometry at Gresham College. A recent biography is Margaret 'Espinasse, 1956 *Robert Hooke.* (Berkeley: University of California Press.)

[49] R[obert] Hooke, 1665, *Micrographia: or Some Physiological Descriptions of Minute Bodies made by Magnifying Glasses. With Observations and Inquiries thereupon.* (London: Jo. Martyn and Ja. Allestry . . .), p. 111. A facsimile of the first edition with the index from the later editions and the preface from Robert T. Gunther's 1938 reprint was published by Dover Publications, Inc., at New York in 1961.

The chamber (camera) casts were known as *spondylithes* or *spondylithos* and at times had been confused with fossil vertebrae.

[50] *The Posthumous Works of Robert Hooke . . . Containing His Cutlerian Lectures, and other Discourses, Read at the Meetings of the Illustrious Royal Society . . . To these Discourses is prefixt the Author's Life* . . . Publish'd By Richard Waller . . . (London: Printed by Sam. Smith and Benj. Walford . . ., 1705), pp. 327ff. The "Discourses of Earthquakes" is crammed with precocious geological and biological ideas on climatic change, past biogeography, extinction of species, and fossils as chronological indicators.

Hooke's views on earthquakes were much influenced by the *Mundus Subterraneus* (1665) of the Jesuit Athanasius Kircher (1602–1680). Kircher's ideas seem to have had a greater effect on the geological notions of the members of the Society than those of his contemporary Steno (Niels Stensen, 1638–1686), whose *Prodromus* was "english'd" by Henry Oldenburg in 1671. Cecil Schneer, 1954, develops this idea in "The Rise of Historical Geology in the Seventeenth Century", *Isis* **45**: 256–268. He argues persuasively and elegantly for recognition of the importance of the fusion of the antiquary-historian and naturalist traditions and the fossil controversy in England in the late seventeenth century, centered in the Royal Society, in forming a considerable part of the background of ideas

(Hooke viewed fossils as the "antiquities" of nature and therefore useful in an older chronology) that produced a science of historical geology by the early nineteenth century.

[51] Edward Lhwyd [Lhuyd, Luid] (1660–1709) who succeeded his tutor Plot as second Keeper of the Ashmolean, and author of *Lithophylacii Britannici Ichnographia* . . . (1699), a catalogue of the figured stones in the Museum, believed them ". . . of the nautilus kind . . ." but wondered what had become of all the species if indeed they were petrifactions. R. T. Gunther, 1945, *Early Science in Oxford, Volume XIV: Life and Letters of Edward Lhwyd.* (Oxford: Oxford University Press), pp. 167–168.

Lhwyd espoused the Spermatic Principle or *aura seminalis* as an explanation of fossil origin; his views should probably be considered organic in nature. Jahn and Woolf (*op. cit.*, pp. 172–173) develop his ideas and objectivity.

[52] Gunther, *Early Science in Oxford* **7**: 712 and plates ff., from p. 285 and plates I and II in *Posthumous Works.* Hooke's arguments (see *ibid.*, pp. 433–436) convinced very few of his immediate audience. Lister, one of the last to assert the inorganic origin of fossils, had used a similar comparison to prove the fossil conchs were merely imitations of the living, and poor ones at that, produced in the earth by yet unknown forces.

Lhwyd, in a letter to Ray (1692), thought ". . . Olaus Wormius was the first that compared any *Cornua Hammonis* to a Nautilus". Gunther, *op. cit.* **14**: 168. Olao (Ole) Worm's [Wurm] (1588–1654) *Museum Wormianum, Seu Historia Rerum Rariorum, Tam Naturalium quam Artificialium* . . . (Lugduni Batavorum: Apud Iohannem Elsevirium . . . 1655), contains a figure of a lytoceratinid (?) whose shape and convolutions are compared to those of the nautilus. See note 78.

[53] Reiske, *op. cit.*, p. 206.

[54] Lang [Langius], 1708, *Historia Lapidium Figuratorum Helvetiae* . . . (Venetiis: Jacobi Tomasini . . .), p. 74. Lang's (1670–1741) spermatic notions of *lapides figurati* are detailed in Jahn and Woolf (*op. cit.*, p. 170), some of which are confusing and contradictory. He eventually came round to a modified diluvial view (through conversations with Scheuchzer?) acceptable to Woodward who thought Lhwyd's ideas nonsensical. There is no evidence that Lang was ever made F.R.S., although in 1725 Woodward offered to recommend him at Scheuchzer's pleasure (Melvin E. Jahn, oral communication, 2 August 1967, based on unpublished letters from Woodward to Scheuchzer and an unpublished translation of Lang).

The "vegetative" ideas of Joseph Pitton de Tournefort (1656–1708), Professor at the Jardin des Plantes, in which "seeds" of *Cornu Ammonis* and other fossils and minerals grew by accretion similar to that of crystals, are outlined by Othniel C. Marsh in "History and Methods of Palaeontological Discovery", an address Delivered before the American Association for the Advancement of Science . . . at Saratoga, N.Y., 28 August 1879, p. 9. Some of the discussion seems to be derived from Parkinson (*op. cit.*, **1**: 31).

[55] Georg Wolfgang Wedel [Wedelius] (1645–1721), botanist and Professor of Medicine at Jena, observes that stones in shellfish form were the actual petrifactions of such shells in ". . . De Conchis Saxatilibus seu Lapideis". *Miscellanea Curiosa. Medico-Physica Academiae Naturae Curiosorum, Sive Ephemeridium Medico-Physicarum Germanicarum. Annus Tertius* [1672]. (Lipsiae & Franconfurti: Sumptibus Johannis Fritzschii . . . 1681), pp. 101ff.

[56] Georg Henning Behrens (1662–1712), *Hercynia curiosa* . . . (Nordhausen: Carl Chr. Nevenhahn, 1703). The quote is from the English edition of 1730: *The Natural History of the Hartz = Forest, In his Majesty King George's German Dominions. Being a sussinct account of the Caverns, Lakes, Springs, Rivers, Mountains, Rocks, Quarries, Fossiles* . . . [translated by John Andree] (London: Printed by W. Pearson for T. Osborne, in Gray's-Inn, Holbourn), p. 24.

[57] Behrens, *ibid.*, p. 159. These Drachenstein (dragon, not drake stones) are undoubtedly ammonites and are not the *draconites* of Pliny (Book 37, Chapter 57) or the medieval lapidaries, which were *lapis a capite draconis extractus*; stones taken from the heads of sleeping dragons or serpents. Leonardi (*op. cit.*, p. 95) refers to them as ". . . *Draconites*, or *Dentrites*, or *Draeonius* or *Obsianus* . . ." which with their black color suggests they may have been obsidian. *Draconites* were specifics against poisons and rendered their possessor ". . . bold and invincible . . ." (Leonardi, *ibid.*, p. 96).

[58] Rumpf, 1705, *D'Amboinsche Rariteitkamer, Behelzende eene Beschryvinge van allerhande zoo weeke als harde Schaalvisschen, te weeten raare Krabben, Kreeften, en diergelyke Zeedieren, als mede allerhande Hoorntjes en Schulpen, die men in d'Amboinsche Zee vindt: Daar beneven zommige Mineraalen, Gesteenten, en soorten van Aarde, die in d'Amboinsche, en zommige omleggende Eilanden gevonden*

worden . . . (T'Amsterdam: Gedrukt by François Halma, Boekverkoper in Konstantijn den Grooten), p. 62 and pl. XVII.

Georg Eberhard Rumpf [Rumph, Rumphius] (1628–1702), soldier, merchant, naturalist, called the *Plinius indicus*, was primarily a botanist who first described in detail the "Cocos-noot" while employed on Amboina (now Ceram) by the Dutch East India Company. A second edition of the "Cabinet of Curiosities" was published in Amsterdam in 1741 by J. R. de Jonge.

See Willy Ley, 1959, *Exotic Zoology*. (New York: The Viking Press), pp. 254ff., for the story of the description of the coconut and a short sketch of Rumpf's career. His accomplishments in the face of a tragic personal life are outlined by Sarton (1937), who reproduces the title pages of Rumpf's major works, in "Rumphius, Plinius Indicus (1628–1702)", *Isis* **27**: 242–257.

[59] Owen, 1832, *Memoir on the Pearly Nautilus* (Nautilus Pompilius *Linn.*) *with Illustrations of its External Form and Internal Structure*. Published by the Council of the Royal College of Surgeons . . . (London: Printed by Richard Taylor . . .).

[60] Rumpf, *ibid.*, pp. 67–68.The argonaut, "Nautilus tenuis", was also the subject of an earlier paper.

[61] Jussieu (1686–1758), of the noted French family of botanists, wrote "De l'Origine et de la Formation d'une sorte de Pierre figurée que l'on nomme Corne d'Ammon". *Histoire de l'Académie Royal des Sciences. Année 1722. Avec les Mémoires de Mathématique & de Physique, pour la meme Année* (A Paris, de l'Imprimerie Royale, 1724), pp. 235–243, in which the resemblance of these fossils to the horns of Jupiter Ammon is noted, the notations in Pliny and Solinus are cited, and the French specimens compared to the living nautilus. Karl A. von Zittel in his *History of Geology and Palaeontology to the End of the Nineteenth Century*. Translated by Maria M. Ogilvie-Gordon . . . (London: Walter Scott, Paternoster Square, 1901), p. 21, indicates Jussieu was less successful in accounting for their occurrence in France; he thought marine transgressions had carried them across the Mediterranean from Siwa. This idea is not included in the above paper; perhaps it was published elsewhere.

[62] Francis C. Haber, 1959, "Fossils and the Idea of a Process of Time in Natural History", *Forerunners of Darwin: 1745–1859*. Edited by Bentley Glass, Owsei Temkin, [and] William L. Straus, Jr . . . (Baltimore: The Johns Hopkins Press), pp. 227ff.

[63] Major General George Twemlow [1867], *Facts and Fossils Adduced to Prove the Deluge of Noah, and Modify the Transmutation System of Darwin* . . . [2v. in 1] (London: Simpkin, Marshall & Co.), p. 28. His apology includes what are probably the earliest photographic illustrations of ammonoids (Twemlow, *ibid.*, unnumbered plate facing p. 120).

[64] Bertrand, *op. cit.*, p. 157.

[65] Caroli a (Karl von) Linné [Linnaeus], *Systema Naturae per Regna Tria Naturae, Secundum Classes, Ordines, Genera, Species, cum Characteribus, Differentiis, Synonymis, Locis* . . . *Editio Duodecima, Reformata* [3v. in 4]. (Holmiae: Impensis Direct. Laurentii Salvii, 1766–1768), **III**: 162. Legal nomenclature dates from the tenth (1758) edition; however its third volume was not published. The MS is now in the possession of the Linnean Society of London.

Of the living cephalopods known to Linné, *Sepia*, including the cuttlefish, squid, and octopus, is placed in Vermes Mollusca; *Argonauta* and *Nautilus* in Vermes Testacea. Of the eighteen species of *Nautilus* given in the twelfth edition, only three are cephalopods, the remainder are foraminifers (Linné, *op. cit.* **I**: 1161–1165). See Henry Dodge, 1953, "A Historical Review of the Mollusks of Linnaeus. Part 2. The Class Cephalopoda and the Genera *Conus* and *Cypraea* of the Class Gastropoda", *American Museum of Natural History Bulletin* **103** (1): 9–15, for a discussion of Linné's cephalopod systematics.

[66] Bruguière (1750–1798), physician, naturalist and Levantine traveler for the Directory, proposed this genus in *Encyclopédie Méthodique. Histoire Naturelle des Vers. Tome Premier* . . . (a Paris: chez Panckoueke, Imprimeur-Libraire . . . 1792), p. 39 and pl. 1. Bruguière (*ibid.*, pp. 28–29) distinguishes two groups of species; nine striated and fourteen unstriated forms. Besides *Ammonites*, his multilocular univalves include *Nautilus*, *Orthoceras* and *Camerina*. Dodge (1947) discusses the validity of Bruguièrean molluscan genera in "The Molluscan Genera of Bruguière", *Journal of Paleontology* **21**: 484–492.

[67] Parkinson, *op. cit.* **3**: 107–108.

[68] *Tableau Élémentaire de l'Histoire Naturelle des Animaux*. (A Paris: Baudouin, Imprimeur du Corps legislatif et de l'Institut national . . . An 6 [1798]), p. 378. The American *Treatise* (1964), *Part K. Mollusca 3*: K12 accepts Class Cephalopoda Cuvier, 1797 as its legal form. "Gasteropodes" is also used for the first time in this classification.

[69] Cuvier, *op. cit.*, pp. 382–383. They were given definite status in the second volume of *Le Règne Animal* in 1817.

[70] *Systêm des Animaux sans Vertèbres, ou Tableau général des classes, des ordres et des genres de ces animaux* . . . (A Paris: Chez L'Auteur, au Muséum d'Hist. Naturelle . . . AnIX–1801), table facing p. 51. Lamarck formally proposed three of these genera, *Orbulites*, *Baculites*, and *Turrilites* in 1799 in a "Prodrome" of his new classification.

[71] It contains *Ammonites*, *Orbulites*, *Ammonoceras*, *Turrilites*, and *Baculites*. *Nautilus* and *Orthoceras* are in separate families; some of the foraminifers are grouped in others. *Argonauta* itself comprises the monothalamous division and the remainder of the internally shelled and shell-less genera form the third division—Sépiares. *An Epitome of Lamarck's Arrangement of Testacea Being a Free Translation of that Part of His Works De L'Histoire Naturelle des Animaux sans Vértebres with Illustrative Observations, and Comparative and Synoptic Tables of the Systems of Linnaeus & Lamarck.* By Charles Dubois. (London: Published by Longman, Hurst, Rees, Orme, Browne, and Greene, 1825), pp. xviii ff. The *Histoire* was published in seven volumes during 1815–1822.

[72] Von Buch, 1832, "Über die Ammoniten in den älteren Gebirgs-Schichten". *Abhandlungen der Königlichen der Akademie der Wissenschaften zu Berlin. Aus dem Jahre 1830* . . ., pp. 136–137.

[73] Dodge traces these developments in "A Historical Review of the Mollusks of Linnaeus. Part 2", pp. 12–13.

[74] Guilielmo (Wilhelm, Willem) de Haan, 1825, *Specimen philosophicum inaugurale, exhibens Monographiam Ammoniteorum et Goniatiteorum* . . . (Leiden: Lugduni Batavorum) [not seen]. De Haan (1801–1855), Curator of Invertebrates in the Leiden Rijksmuseum of Natural History, best known for his work on crustaceans and insects, proposes the genera *Goniatites* and *Ceratites* in this work, originally his doctoral thesis. See the biographical note by L. B. Holthuis, 1953, "On the Dates of the Publication of W. de Haan's Volume on the Crustacea of P. F. von Siebold's 'Fauna Japonica'". *The Journal of the Society for the Bibliography of Natural History* **3**: 45–46. *Specimen* is discussed in von Buch's "Über Goniatiten". *Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin. Aus dem Jahre 1830* . . . 1832, pp. 159ff., where de Haan's concepts of the taxon are reviewed and modified on characters of the sutural lobes.

[75] Christian Leopold Freiherr von Buch (1774–1853), renowned naturalist, traveler, geologist, and paleontologist, student of Werner at Freiburg and intimate of Alexander von Humboldt. His brilliance, wide interests, and accomplishments have been the subject of many biographies; see W. Lambrecht and W. and A. Quenstedt, 1938, "Palaeontologi. Catalogus bio-bibliographicus". *Fossilium Catalogus* **I**: *Animalia.* (Pars 72) Editus a W[erner] Quenstedt. ('s-Gravenhage: Dr W. Junk), p. 65, for a list of authors.

[76] Von Buch, "Über de Ammoniten . . . ", pp. 137–138.

[77] Owen, *op. cit.*, pp. 56–57. Owen lists the synonymous taxa of Lamarck, de Blainville, de Haan, and d'Orbigny.

[78] François-Jules Pictet de la Rive (1809–1872), Professor of Zoology and Comparative Anatomy at the Geneva Academy and National Councilor in Bern, who studied under Cuvier, St Hilaire and de Blainville among others, published a number of papers on fossil molluscs, brachiopods, insects, echinoderms, and reptiles. His two greatest works are the series of researches which form the *Paléontologie Suisse* and the four volume *Traité Élémentaire de Paléontologie ou Histoire Naturelle des Animaux Fossiles* . . . (Genève: Imprimerie de Jules-Guillaume Fick, 1844–1846). In the latter, cephalopods are divided into two orders, "Acétabulifères" and "Tentaculifères", the latter containing five families, one of which is "Ammonitides" (Pictet, *ibid.* **II**: 309ff.). The large number of species in *Ammonites* are grouped into twenty subgenera after the arrangements of von Buch and d'Orbigny (Pictet, *ibid.* **II**: 353ff.). In the second edition of the *Traité* (1853–1857) the species are placed in twenty groups in six sections. The general discussion of the genus is expanded to include a brief discussion of "Ammon" and a long list of eighteenth-century workers. Pictet also includes a statement that Belon in 1553 compared cornes d'Ammon to the nautilus. *Traité de Paléontologie* . . . *Seconde Édition* . . . (A Paris: Chez J.-B. Baillière . . . 1854), **II**: 664. As Belon's *De aquatilibus* was not available to me, I have not been able to verify this comparison.

[79] *Palaeontology or A Systematic Summary of Extinct Animals and Their Geological Relations.* By Richard Owen, F.R.S. (Edinburgh: Adam and Charles Black, 1860), p. 87.

[80] Suess, 1866, "Über Ammoniten", *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften. LII. Band I. Abtheilung. Jahrgang 1865.-Heft VI bis X*, pp. 71–89. Sarton (1919) gives a brief personal sketch of Suess and lists more detailed

biographies as part of his discussion of *Das Antlitz der Erde* in "La Synthèse Géologique de 1775 à 1918", *Isis* **2**: 381ff.

[81] "Opinion 305. Suppression under the Plenary Powers, of the generic name *Ammonites* Bruguière, 1789 . . ." *Opinions and Declarations Rendered by the International Commission on Zoological Nomenclature*, 1954, **8** (22): 297–312. William J. Arkell discovered the lectotype on which *Ammonites* Bruguière, 1789 rested, based on a specimen figured by Martin Lister in 1685, was unidentifiable generically from the original illustration. It had greater affinities for *Arietites* Waagen, 1869 than *Ammonites* as revived by Buckman in 1923.

[82] Those not mentioned include Friedrich August von Quenstedt, Carl Albert Oppel, William Buckland, Alphonse Milne-Edwards, Rudolf Richter, Emil Philippi, Carl Eduard von Eichwald, and Fridolin Sandberger among others prior to 1865, and Wilhelm Heinrich Waagen, Melchior Neumayr, Johann Mojsisovics, Hyatt, von Zittel, and the Buckmans, James and Sydney Savory, before the end of the century.

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[84] (Note added in proof) Willy Ley, 1968, *Dawn of Zoology* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc.), p. 198 suggests distractions and Gesner's ill-health while writing *De Rerum Fossilium* (he died a few months after its completion) explain its uneven quality (see note 31) when compared to his earlier works. Dr Ley has also recently written an introduction for the Da Capo Press's (New York, 1967) handsome facsimile of the 1658 London edition of Topsell's *The History of Four-Footed Beasts and Serpents and Insects* (see note 35) to which Thomas Mouffet's [Muffet, Moufet] (1553-1604) *The Theater of Insects* (1634) was appended as the third volume.

The British Museum (Natural History) published last year as No. 658 *The Early History of Palaeontology*, a significantly revised and expanded version of Edwards's popular *Guide* (see note 41) by Dr Errol I. White, former Keeper of the Department of Palaeontology.

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