

Maurizio Forli · Andrea Guerrini

# The History of Fossils Over Centuries

From Folklore  
to Science



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*Once again to Maria Teresa e Rita*

# Preface

When in 2013 I was given for Christmas the book of Professor Giancarlo Baronti *Between children and dirty waters: Immersions in the collection of amulets of Giuseppe Bellucci*, I would not have imagined that, 4 years later, I would have been inspired to write a book on fossils, their meaning, their understanding over time, and their multiple nature according to particular keys of interpretation, which go beyond the common way of thinking about them.

The content of that book, in addition to fascinating me, was therefore the primary cause of the drafting of this text. To all this has joined my interest in fossils and paleontology in general, some multiform naturalistic knowledge that I have acquired over the years and a friendship grown and consolidated in the last decade, with Andrea Guerrini, the other author who has given me the pleasure of writing these lines. Our collaboration is therefore the other cornerstone of the formation of the work. But which “work” are we going to present to you?

After this preamble, either you are curious or you have already closed the book. So, hoping for the first hypothesis, I tell you at once that we have chosen to begin our studies by doing a bibliographical and above all iconographical research aimed at finding the first printed images of the objects that today we know as *fossils*: who was the first person to illustrate an ammonite, a shell, a shark tooth, and so on? Since the field of study is so vast, we have therefore limited ourselves, without missing any exceptions, to carrying out research on invertebrates in general, because it is they who will accompany us both in the history of understanding the true nature of fossils, and in the complex relationship existing between “academic” and “popular” science up to the present day, in which the latter has almost always been transformed into an unconscious habit.

We finally decided to conclude the treatment of each group when the ancient, petrified organisms were recognized as such and thus assigned and included in the present classification.

We could have found a thousand other ways to explain our thought, but the path we have chosen, reporting extensive original quotations more or less ancient and plausible, is the one that seemed the best we could go. So, to sum up, we propose a “collection of ancient prints,” starting from the late fifteenth century, dedicated to

the most common groups of invertebrates, fossils systematically described according to current scientific knowledge, and “fossils” instead considered medicinal substances or special stones with apotropaic properties. Lateral points of view that make you curious but also better understand how all topics can and should be addressed and understood totally. There is no contradiction in dealing in the history of paleontology also with paintings, archaeological finds, legends, invertebrate anatomy, fossils and folklore, and magic. They are all aspects of our knowledge, even inner, determined by science, knowledge as such, collective and individual. Starting from the atoms that make up the matter of books, one can arrive at the psychology of the author, the reader, and their place in the universe. An absurd path? probable, but, if probable, it can be done.

Not being historians of paleontology, for the treatment of the argument, we have naturally availed ourselves of the opinion of the scholars who have made it their profession. In conclusion: we have tried to use “the art of not inventing anything” to invent this whole of ours, consisting of the pages that will follow.

Prato, Italy

Maurizio Forli

# Presentation

Maurizio Forli and Andrea Guerrini proposed me to present this manuscript with the typical modesty (but also the enthusiasm ... and the infinite patience!) of those who have not followed the *Cursus Honorum* of academics but the Sacred Fire of their own passion, born almost always during childhood or the years of youth, and of those who have accumulated a profound knowledge of fossils through endless explorations of gullies, quarries, and rock faces, adventurous collections of specimens dug out of the sediment that has preserved them for millions of years, long and tiring days of work to wash and sift even the smallest specimens, removing the cemented matrixes to isolate even apparently insignificant fragments and re-compose entire specimens, and many hours of their free time dedicated to the microscope to measure, determine, and catalogue the fruit of their labors and to study the scientific literature.

Precious artisans of paleontology and irreplaceable connoisseurs of their own territory (in both cases especially the rich Tertiary lands of Tuscany), the so-called “paleontophiles” like Forli and Guerrini are fundamental collaborators of researchers for the richness of their collections, which they willingly make available (and much more often than is believed they give to museums), and for the glance of the country naturalist, increasingly rare in the career researcher, oriented towards the “maximum systems” and affected by bulimia from publication, under the banner of the Anglo-Saxon publish or perish.

The nearly 400 pages of this journey through the history of fossil interpretation are written with the same spirit and punctiliousness that the authors themselves devote to determining each and every specimen in their collections.

What follows is not an essay on the history of science, although it is precisely the history of palaeontology that we are talking about; rather, the historical-scientific literature is a tool for contextualizing the immense repertoire of textual, iconographic, and anecdotal sources and creating a solid basis for the narrative.

Because this is narration: the authors participate in first person in this journey through the centuries, when they stimulate the reader to imagine the character of the “sanpaolaro” (a small pearl among the many that are discovered among these pages) and immediately afterwards entering directly into the scene with the description and



the photo of a precious souvenir made by the Procidan grandmother of one of the authors.

A narrative device that through the tasty “inserts” recurs up to the afterword—in my opinion with great effectiveness—through which the reader is put at ease until he realizes that he no longer feels awe (respect yes!) for Pliny, Leonardo and Cuvier that mark the path, but can abandon himself to the imaginative world made of magical symbols, religious and archaic rites, the atmosphere almost Proustian and welcoming family memories.

The originality of this work lies above all in this skillful interweaving of the natural sciences and the humanities, from archaeology to literature and popular traditions, which makes it interesting both for the encyclopedic specialist, who can find the answer to many questions here and perhaps even stimulate new ones, and for those who are approaching these subjects for the first time as simply curious.

In this effort to cover all the points of view through which fossils have been interpreted over time, Maurizio and Andrea are ideally close to the Renaissance scholars widely quoted throughout the text, Agricola, Gessner, Calzolari, Mattioli, and, above all, Ulisse Aldrovandi, not so much the partly reworked *Museum Metallicum* or the printed *Monstrorum Historia* to which he owes his alternate posthumous fortune but the one who personally edited the autograph *Ornithologiae* and above all the *Theatrum Naturae*, the impressive project of representing nature in all its forms and artifices that he tried to recreate in his museum.

Happy reading!

Alessandro Ceregato

# Acknowledgments

We would like to thank all those who have supported us with pictures, advice, as well as direct and indirect contributions, and apologize to those we may have forgotten to mention.

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Andrea and Maurizio  
(Livorno & Prato, 17 February 2022)

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## Short Biographical Notes

**Maurizio Forli** (Rosignano M.mo, Leghorn, 1954). Independent researcher, always been interested in natural sciences, with preferences for paleontology and malacology. Various graphic and artistic experiences. Curator of the organization and staging of numerous expositions, conferences and cultural initiatives, he has so far published, over forty scientific articles of fossil malacology and numerous others in various magazines and journals. Co-author of books on the Italian Plio-Pleistocene malacofauna, particularly from Tuscany, has recently published with Andrea Guerrini “Storia Naturale della Toscana” and with another co-author “The family Rissoidae Gray, 1847 from Miocene to Present-day in the Mediterranean basin” (Danaus Editions). Active member of the Gruppo Archeologico e Paleontologico Livornese, he is member of the Italian Paleontological Society and of the Società Italiana di Malacologia.

**Andrea Guerrini** (Leghorn 18/2/1968). Radiology Technician and graduated in Natural Sciences in 2007 (University of Pisa), scholar of Paleontology, he attended the online courses BipedalismX Course: The Science of UprightWalking – Dartmouth University (Prof. Jeremy DeSilva), ASM246x Human Origins Course – Arizona State University (Prof. Don Johanson) and Forensic Archaeology and Anthropology – Durham and Teesside University. He is a member of the Italian Paleontological Society, Società Toscana di Scienze Naturali and an active member of the Gruppo Archeologico e Paleontologico Livornese. He is the author of papers on palaeontology and on paleoradiology. He is co-author of the book of palaeontology “Storia Naturale del Pianeta Terra”, Vol. I and II (Pacini Publisher) and “Storia Naturale della Toscana” published with Maurizio Forli (Danaus Editions).

# Chapter 1

## Toad's Eyes, Devil's Nails, Snake Tongues...



**Abstract** The discovery in the past of strange and unknown petrified objects has given rise to many legends and superstitions since the remotest antiquity. Before recognizing fossils as the remains of ancient beings who lived in the more or less remote past, scholars of natural things had to struggle at least until the beginning of the nineteenth century. At the same time, popular culture has continued to maintain the ancient knowledge to this day, remembering part of the ancient rituals. We report some testimonies.

**Keywords** Fossilia · Fossil · Toad's eyes · Devil's nails · Snake tongues

*Toad's eyes, devil's nails, snake's tongues*, etc. this list of ingredients, apparently fanciful and repugnant, could be the beginning of a magic recipe like the ones we sometimes hear about in films or read in fairy tales or in novels. From the point of view of this text, in reality we are dealing with nothing more than fossils, called by the name by which they were known hundreds of years ago, feared, or appreciated, according to their use for different purposes.

The discovery in the past of strange and unknown petrified objects has given rise to many legends and superstitions since the most remote antiquity, as people could not explain their origin. In historical age, from the Egyptians to the Romans, the studies and the magic religious experiences, or linked to a sort of primitive medicine, have made that a lot of these news, often borrowed through fanciful tales more and more improbable, have given origin to myths, today often brought back to their original meaning, once understood and correctly interpreted the fossils connected to them.

An almost inexhaustible source of the most varied information, which has strongly influenced the research carried out since the medieval alchemists, is the *Naturalis Historia* of Pliny the Elder, a Roman author of the first century AD (23–79 AD), who in his work in more than 30 volumes, bringing together from various sources the knowledge of his time and his own observations, laid the foundations for the continuation of this knowledge.

Beliefs and superstitions related to particular stones endowed with strange shapes, among which our fossils, strengthened and developed in the European area,

especially during the Middle Ages, often with conflicting interpretations, linked to aspects of religiosity. In this context, contrary to the positive virtues usually attributed to gems and similar stones, a whole series of petrified remains can be found which, precisely because of their appearance and mysterious genesis, were often interpreted as manifestations of the “Evil One” and, as such, played a role both in defeating and searching for him, even though they were often used as medical matter, antidotes or amulets.

These particular stones characterized by special shapes, crystals, simple rocks, or fossils, due to their external morphology, according to a common use at the time that saw in things a mysterious ambivalence, *an* opposite duplicity (*natura ancipite*), were also considered bearers of signs that revealed properties hidden in them by nature or by the intervention of the saints and therefore endowed with symbolic meanings and magical and therapeutic virtues. In the field of medicinal magic, a method of treatment based on the use of plants in particular, but also of minerals and fossils, according to their similarity of shape and color with parts of the human body, has been very popular since ancient times. There would be a link between all natural things, including the stars, which would bind those with similar functions or with the same appearance, recognizable by particular common signs, which would ensure that, for example, a plant with parts resembling parts of the human body, can be effective and therefore used to cure or protect the organs with which there is similarity or, on the contrary, spoil them permanently leading to death. From these concepts was perfected in the course of time the so-called theory of signatures on which physicians and official apothecaries were based. In the poorer and less educated social classes, culturally backward and superstitious, folk medicine was handed down mainly by some women who prepared remedies with herbs or other substances and often acted as midwives. It was they who, in case of particular conditions of hardship in the communities where they practiced, such as famine, plague, or episodes considered criminal, risked being identified with those mythological figures much feared in the collective imagination, endowed with occult magical powers derived from the pact with the devil, called witches. In recent times, still in the 1960s and 1970s, for direct testimony (FM), my paternal aunt Settimana was called to cure small diseases or remove the evil eye, similarly to others who continue to practice their medicine even in our days. We report a rare case in which is testified the use of fossil shells for these popular practices:

*Da noi sono sempre delle donne, delle donne di una certa età; come anche per la medicina dell'occhio, dove si usa un fossile, si fa una preghiera sopra un bicchiere con questo fossile, generalmente sulla testa o a fianco di chi deve essere pulito, della persona a cui deve essere tolto l'occhio, diciamo, e sono sempre donne che lo fanno e sempre di una certa età. Alcune situazioni non vengono mai chiarite; ci sono sempre quei, come ti posso dire, quei piccoli misteri.*

[...] *il malocchio è un qualcosa che energeticamente tu vedi da determinati segni. Io lo sai come lo vedo? Quando butto la pietra, questo fossile nell'acqua, si formano un tot di numeri di bolle e a seconda della grandezza e dell'ubicazione della bolla viene fuori il tipo anche di malocchio.* (De Bernardi 2015: 322, 333)



*With us it is always women, women of a certain age; as also with evil eye medicine, where a fossil is used, a prayer is made over a glass with this fossil, generally on the head or beside the person who is to be cleaned, of the person whose evil eye is to be removed, let us say, and it is always women who do it and always of a certain age. Some situations are never cleared up; there are always those, as I can tell you, those little mysteries.*

*[...] the evil eye is something that energetically you see by certain signs. Do you know how I see it? When I throw the stone, this fossil in the water, a number of bubbles form and depending on the size and location of the bubbles, the type of evil eye also emerges.*

Some fossils were believed to be components of magic potions or evil in themselves, but, as well as being taken in various ways to cure and heal illnesses and diseases, they were used as amulets with multiple properties, for example, to defeat the devil or remove the evil eye. This way of understanding and using fossils as magical or medicinal ingredients has gradually diminished and been lost over the last three centuries. On the contrary, popular knowledge and superstitious practices oriented to the use of stones and minerals in general to prevent and cure various ailments or for their beneficial astral influence are increasingly spreading, especially through the web. A sort of cultural revival that finds millions of admirers and users of these natural substances, believed to be bearers of who knows what positive properties, perhaps linked to the signs of the zodiac, in such a way that follows more or less slavishly the medieval and even more ancient knowledge.

This can only be surprising because today it is widely demonstrated that certain magical properties, often even therapeutic properties of said stones or fossils, were and are absolutely nonexistent... yet the general culture is considerably higher than that of medieval and modern populations. With the economic, scientific, and cultural progress, we would expect a less diversification of the religious cults and a decrease of the superstitious beliefs, but probably, the decrease of the dominant religious practice is counterbalanced by an increase of the superstition, meant as regression to previous stages, to which the religion has replaced and superimposed itself, instead of a parallel reorganization of both.

The study of fossils implies more or less close links with different sciences such as palaeontology, geology, physics, anthropology, ethnology, philosophy, evolutionism, which, developing more or less at the same time, have allowed the elaboration of current knowledges.

In the notes that follow, compiled also and above all by consulting ancient books, scientific articles, and news on the web, we gather information and notes on many fossils unknown to most people, known only to lovers and scholars of paleontology, geology, or natural sciences, in order to convey what little we know, in a unicum reasoned built by assembling critically, and we hope in a relevant way, dozens and dozens of sources, according to today's scientific canons even if, sometimes, we have lingered on those *magic* and *curious* things that still attract many of us, aware that however they are also an important cultural heritage that is part of our history, trying to look at fossils as a subject, visible not only from the naturalistic side but also from other, apparently distant, that lead the thought to investigate in unexpected fields to a superficial and unidirectional vision and understanding (Fig. 1.1).



**Fig. 1.1** Internal molds of fossil bivalve shells, carried in pockets as lucky charm in some Italian regions (e.g., Sardinia and Tuscany). Average shells width 5 cm. (Photo Maurizio Forli)

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## Chapter 2

# *Fossilia* and Fossils: Considerations on Their Understanding Over the Centuries



**Abstract** At present it is quite obvious that fossils are the remains of ancient organisms, but it was not always so. The conception of the origin of fossils has been the subject of antithetical interpretations, as early as the classical age, which can be summarized to simplify into two main categories sometimes not clearly separated, called inorganic genesis and organic genesis. These interpretations have been intertwined with each other, prevailing now one or the other, until the confirmation of organic genesis during the eighteenth century at least for the most recognizable and widespread organic remains. It was mainly in Italy that these new currents of thought took shape in the course of the sixteenth century and then spread later throughout Europe, which will prove fundamental for the development of the natural history studies. In this respect, in the chapter we will try to make a brief overview by mentioning the various authors and their works, who contributed most to the *quaestio de fossilibus* and thus also to the development of the embryonic stages of earth sciences. It is in their publications that we also find the first printed illustrations concerning fossils, the recurring theme of our text. These authors, in particular of the sixteenth and seventeenth centuries, were still far from the concept and definition of the term paleontology, used for the first time in 1822 by de Blainville, but they are to be considered, among the founders of this discipline. It was only early of the nineteenth century that the term fossil took on its current meaning and toward the end of the nineteenth century, with the rise of evolutionary ideas and the awareness of the expansion of the past, that fossils were definitively considered and studied as remains of ancient populations subject to the same laws of biology that regulate today's living beings.

**Keywords** *Fossilia* · Fossils · History · Understanding over the centuries

For many of us, it is quite obvious that fossils are the remains of ancient organisms, but it has not always been so. This concept has been formed and consolidated with difficulty over time, starting from the beginning of the modern age, as a consequence of different paths and sometimes opposing ideas on the same subject, although based on the same knowledge.

There are countless ancient and current writings on the subject by more or less important philologists, philosophers, and historians of the natural sciences, investing the religious and scientific aspects of human knowledge, with the many implications that follow.

On the other hand, a hint of how our predecessors considered fossils, we believe it is essential to clarify the concepts according to which, even in the first printed texts, these are, by naturalists who began to study them, putting them in some order, identified as single lithified objects and as such included in different groups depending on whether they were whole organisms or their partial remains. It is not infrequent, in fact, that invertebrates such as sea urchins, corals, or shells are listed and described in different categories depending on the appearance they took in the case they were whole or fragmented.

Human beings have the ability to lead back to known images, and therefore to objects or people “present” in our mind, those structures, shapes, and random appearances that every now and then are proposed to us. We believe that this is the mental mechanism that has transformed the casts of bivalves into ox hearts or vaginal openings, the discoidal shells of macroforaminifera into coins or lentils, some corals into petrified mushrooms, the teeth of sharks and the rostrums of belemnites into points of lightning, the spirals of ammonites into snakes, and so on.

Following the trend of influences that naturalistic thought underwent over the centuries, the concept of the origin of fossils has been the subject of antithetical interpretations, which can be summarized into two main categories called inorganic genesis and organic genesis. These interpretations have been intertwined with each other, prevailing now one or the other, until the final confirmation of organic genesis during the second half of the seventeenth century.

The current vision, accredited in the scientific community, of a planet Earth as an open and dynamic system, in continuous biological and geological evolution, represents the culmination of a series of intellectual processes and objective findings that have accelerated since the mid-nineteenth century, a period in which naturalistic and philosophical concepts, basic for today’s understanding and comprehension of natural history and the world in general, became explicit and consolidated. Although they were used in prehistoric times as pendants, for the production of jewelry or as tools, it is believed that a conscious interest in fossils in Western Europe cannot be prior to the pre-Socratic philosophers, although the contents derived from written evidence, present as quotations and fragments, are of uncertain interpretation:

*These authors were the first to begin to examine them concretely, and particularly because of their common occurrence, they referred mainly to petrified shells. Free from all prejudices, they drew from them conclusions of importance to natural history rarely departing from the truth even as to their petrification and actual nature.*

*It is certain that Xenophane [...] remarked as a particular phenomenon, that petrified shells are found in the bosom of the Earth and in the mountains, and that from the quarries of Syracuse were taken remains of all species of marine animals. Thus he concluded that all these places had been covered by marine waters. Herodotus, one of the oldest historians, [...] knew the shells in the mineral kingdom, so well, that of those which were found on the Egyptian mountains, he believed he could affirm that the sea had withdrawn there little by little. Others, mainly Eratosthenes, Xanthus of Lydia, Straton and Strabo drew the same*

*conclusions about the petrified shells, concerning all the land, now inhabited, [...] They speak of Pectinites and other remains of marine animals, naming the places where they were found, thus proving the great knowledge they had [...] Pausanias put the petrified shells among the most remarkable things he saw in his travels, as it seems very clear from a passage of his work. It seems evident that in Greece, the lovers of Nature knew the petrified shells, that they considered them as natural bodies, which afterwards were changed into stone, and although they were not able to determine the causes of this change, they did not leave, even with little knowledge, to make very important cosmological observations and conclusions.* [Walch 1768–1773: pp. 17–18 (translation from the original in French)]

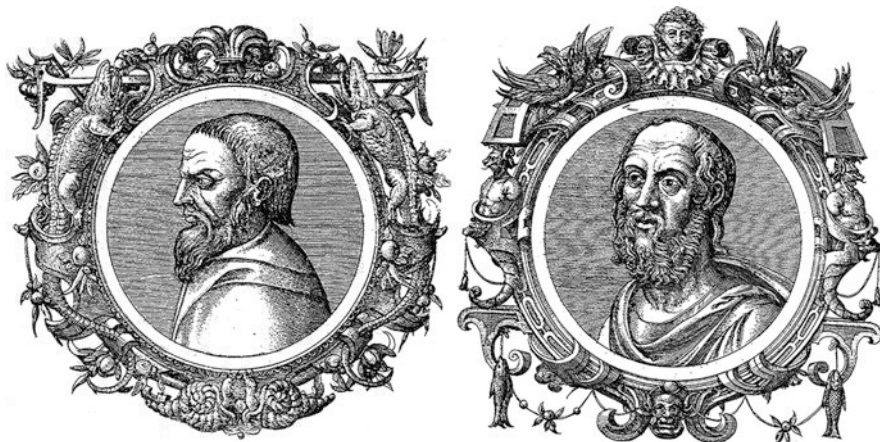
In addition to this view of the nature of petrified bodies, it is possible to find, in the lapidaries and treatises on medicine and natural history of the classical age, another particular view of these objects. In this regard, we remember Aristotle's thought [IV century BC (384–322)], with the theory of celestial influences, which is opposed to that of the abovementioned authors according to which petrified bodies would be spontaneous products of the earth, through a more or less mysterious *vis formativa* activated by “dry exhalations” of the earth itself, produced by the action of solar rays. On this theory, expressed in the *Meteorologica*, is based a writing, the *Peri lithon*, by his pupil and successor Theophrastus (371–287 BC), which had a lot of credit in medieval times:

*the Peri lithon (On the stones) provides a detailed description of sixty different types of solid materials, meaning minerals, gems, clays, rocks, earths and even pearls, all solid materials that can be extracted in mines, quarries or however from the subsoil, excluding metals. It is the first mineralogical treatise ever written (ca. 315 B.C.) and it is also the first to be printed (February 1497, by Aldo Manuzio).* (Mottana and Napolitano 1997)

Also related to this interpretation of their nature, because of the contradiction inherent in having organic appearance, but stony substance, some of them assume properties and a magical dimension-therapeutic, becoming special stones also as components of traditional pharmacopoeia. In this regard, we remember the *Naturalis Historia* of Pliny where the emphasis is also placed on the symbolic meaning of their morphology and the ways in which they would have acquired these virtues.

This Plinian literature, together with other works such as Lucretius' *De rerum natura* (first century BC) and Seneca's *Naturales quaestiones* (first century AD), defined as “meteorological” because it recalls the homonymous work of Aristotle, arrives as compendiums or extracts until the early Middle Ages, influencing also the opinions of the masters of the cathedral schools such as the Spanish theologian and archbishop Isidore of Seville (560–636) and the Anglo-Saxon Christian monk and historian Bede the Venerable (673–735). This type of writings, although sometimes enriched by the experiences of the authors, in general remains works lacking in organicity and limited in the area of Plinian derivation (Fig. 2.1).

As early as the sixth century, monastic communities had introduced the copying of ancient manuscripts into their *work*, but a great process of mediation between classical culture and the West was carried out from the eighth century onward by the Arabs. The Arabs, by promoting the process of translation and commentary on the philosophical and scientific works of the Greeks, also in the conquered lands, particularly in Spain, promoted knowledge throughout the Latin West (Fig. 2.1).



**Fig. 2.1** On the left, Aristotle, the philosopher also known as the Stagirite, from his hometown of Stagira, in the Peloponnese, and on the right, Gaius Pliny the Second, better known as Pliny the Elder. Medallions with portraits, modified after *Icones veterum aliquot, ac recentium medicorum, philosophorumque elegiis suis editae* by János Zsàmboki, Latinized as Janus Sambucus (1574) [<https://babel.hathitrust.org/cgi/pt?id=gri.ark:/13960/t0dv92j6f&view=1up&seq=8> (Public Domain)]

Regarding the origin of petrified bodies, in the course of time, also other theories found credence beyond that of Aristotle as, for example, the *vis plastica* of Avicenna (980–1037) according to which the petrified organic remains were nothing but abortions of nature that would have been able to shape them but not to infuse them with life:

*Avicenna, in the tenth century, contributed not a little to enriching and consolidating this absurdity, [...] in what he called Vis Plastica. As Aristotle supposed an equivocal or spontaneous generation, and it was natural that the advocates of this idea should suppose a certain virtue. A virtue which was commonly called Vis Plastica and in regard to the Mineral Kingdom Vis Lapidifica. (Walch 1768–1773: p. 19)*

However with the Middle Ages, a long phase opened in which in the first part of this period, conditioned by the progressive disintegration of the Roman Empire, by the invasions and migrations of different peoples, there were no favorable conditions for the development of studies or researches and the interest toward natural phenomena was very scarce. The dominant philosophy, based on biblical arguments, in particular derived from the first chapters of the *Book of Genesis*, was that the history of the earth was short-lived and the expression of a “recent” creation.

Around the twelfth century, again in the West, there was a general awakening from the cultural point of view, the first universities were founded, and through *scholasticism*, which was medieval philosophy and theology, there was a mixture of ancient Greek, Latin, and Arabic science and the universal hegemony of Christian culture. There is always a sharp separation in approaching the study due to the dualism between popular religious culture and that of the learned in the universities,

which leads them to profoundly different conclusions. In the first case, it is believed that through the intervention of the saints, animals, plants, and stones are endowed with magical and symbolic virtues, while the wise interpret and explain these properties through the dictates of the philosophy of Platonic, neo-Platonic, hermetic, and Aristotelian concepts, the doctrine of signatures of Plinian derivation, the arrangement of the stars, and their influence between the macrocosm and microcosm of man. In a divinely created universe in which all parts are connected through a dense network of hidden affinities, with the whole fused into a coherent whole, correspondences can be manifested by similarities and analogies not only between microcosm and macrocosm but also between heaven and earth, between animals and plants, and between living and nonliving entities. The nascent science is presented as natural magic.

On the basis of this, therefore, easily identifiable marine bodies, especially shells, are considered traces of the universal flood, while others, although still marine but difficult to conceive, are believed to be particular figurative stones, produced in the place where they were found by celestial phenomena or by the ground itself, in peculiar astral conditions, on the basis of what has been said above. In this context the Dominican bishop Albertus Magnus (~1206–1280) had an important role in separating the sources of discussion of theology from those of philosophy, differentiating their respective fields and attributing to the latter the study of nature in its various articulations. To this interest he applied what was then a new methodology of study, experimenting and investigating directly into the causes operating in nature, no longer relying solely on the authority of ancient writers and their presumed veracity. Despite this, his opinion on the formation of fossils, starting from the Aristotelian legacy, based on a *virtus mineralis lapidifica formative* infused by the stars, was harshly criticized by Agricola in his *De ortu et causis subterraneorum* (Ottaviani 2000):

*His formative Virtus is the Vis Plastica of others. He himself admits that this formative virtue has no particular name, and that each of its supporters believes himself entitled to give a name to his fantasy [...] Nevertheless Albert the Great, does not entirely deny the possibility of the petrification of animals, which would be done by means of a petrifying virtue, which he called Mineral Virtue. (Walch 1768–1773: p. 19)*

The agreement between nature and the Bible, but with the action of celestial forces, is also evident in a writing of the contemporary Ristoro d'Arezzo, the *Composition of the World*, manuscript in several copies of 1282 remained unpublished until 1849, according to which all inorganic bodies derive from celestial influences that guide and determine the mixture of elements that form the material diversity. In dealing with the origin of mountains, he believes that the shells, which he calls *fish bones*, contained in them, derive from the biblical Flood, which occurred by the conjunction of water stars, but also from the previous presence of seawater or their similarity:

*And now we see the generation of mountains [...] And also the mountain can be because of the water of the deluge, which being the water of the deluge, and covering the earth and remaining on the earth, because of the wind or other reason, can take the earth from one place and put it in another; therefore it is the nature of the water, if it is kept on the earth, to make the mountain and the valley, and it is its nature to leave the earth mountainous and*

*valley-like [...]. And we have already found and excavated, almost to the sum of a very large mountain, many fish bones, which we call snails, and such they call niches: which were similar to those of the painters, in which they hold the colors [...]. And that area where there are these mountains, where there is the sand and the fish bones, is a sign that in that area was already the sea, or water like the sea [...].* (Restoro 2: 6, 8 in Narducci 1859: pp. 85–86)

Another testimony on the same subject concerning ancient Tuscany, after Restoro, is in Giovanni Boccaccio (1313–1375). In *The Filocolo* (1336), Boccaccio, in an allegorical way, highlights the presence of a great quantity of fossil shells in the hills around Certaldo, his native town, attributing them to the Flood:

*Nella fruttifera Italia siede una picciola parte di quella la quale gli antichi, e non immerito, chiamarono Tuscia, nel mezzo della quale, quasi fra bellissimi piani, si leva un picciolo colle, il quale l'acque, vendicatrici della giusta ira di Giove, quando i peccati di Licaon meritavano di fare allagare il mondo, vi lasciò secondo l'opinione di molti, la quale reputo vera, però che ad evidenzia di tale verità si mostra il picciolo poggio pieno di marine cochiglie [...] biancheggianti tutte.* (Squarzafico 1497, 5: p. 8)

*In the fruitful Italy sits a small part of that which the ancients, and not undeservedly, called Tuscia, in the middle of which, almost between beautiful plains, stands a small hill, which the waters, avengers of the just wrath of Jupiter, when the sins of Lycaon deserved to flood the world, left there according to the opinion of many, which I believe to be true, however, as evidence of this truth shows the small hill full of sea shells [...]. whitening all.* (Squarzafico 1497, 5: p. 8)

With the progressive estrangement of Islamic civilization from the West, which began in the late Middle Ages, a new cultural phase developed. There was an obsessive search to recover the originals of ancient Greek texts, even those that were obscure or thought to be lost, in order to be able to make new translations to replace the medieval ones, in the certainty that a translation into correct Latin, starting directly from the original language, was more valuable than one from the twelfth or thirteenth century, considered to be corrupted by the mediation of the Arabic language in these versions [...] (Boas 1973: p. 12). By the middle of the fifteenth century, this great research had practically come to an end, and the fall of Constantinople in 1453 at the hands of the Turks closed the door on the surest and richest source of such works (Ibid. 17). All this allowed the scholars of the fifteenth and sixteenth centuries the correct interpretation of the texts, thus also developing the scientific culture, especially in the pharmaceutical medical field, but also naturalistic.

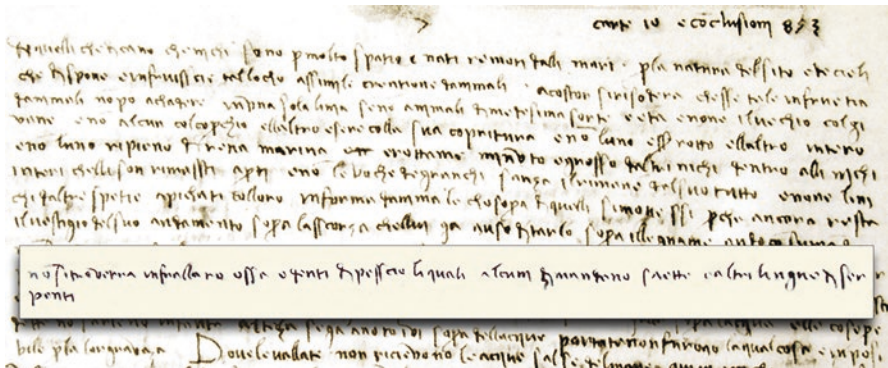
At the beginning of the sixteenth century, Leonardo da Vinci had conceived, with intuition and logic, original ideas both on the nature of fossils and on geological phenomena. To him we owe their rational interpretation in a paleoenvironmental and geological context that was at least two centuries ahead of the history of geological sciences (Raffi and Serpagli 1993). These concepts are expressed by notes, annotations, and drawings scattered in numerous manuscript sheets and in particular in the collection called *Codex Leicester*, also known as the Hammer Codex,



where memories of experiences and observations made while travelling through the hills and valleys of Tuscany, Romagna, or the Po Valley often appear. Leonardo rejected the ideas of those who believed that niches, i.e., shells, were formed by a particular plasma power of the soil or the stars. He observed that it would not be possible to find together in the same place, as in fact happens, whole or shattered specimens of young and old *niches*, distinguishable by age on the basis of the number of growth lines on the surface of the shell, as Leonardo himself discovered, sometimes mixed with fish bones and teeth, recognized as such, thus affirming the animal origin of the remains called *lightning bolts* or *snake tongues*, decisively rejecting also the diluvial theory with numerous arguments (Fig. 2.2):

*se non fossero stati accumulati lungo un antico lido dalle onde del mare [...] d'altri nichii dentro alli nichii interi [...] non si troverà infra loro ossa e denti di pescie, li quali alcuni dimandano saette, e altri lingue di serpenti [...] se il diluvio fu per pioggia che ingrossò i fiumi o per ringorgamento del mare. [...] li nichii, come cosa grave non son sospinti dal mare alli monti, né tirati a sé dalli fiumi contro al corso delle loro acque.* (Codice Leicester, probabilmente scritto tra il 1504 e il 1510, in particolare foglio 9 r)

*if they had not been accumulated along an ancient shore by the waves of the sea [...] of other niches inside whole niches [...] one will not find among them bones and teeth of fish, which some call lightning, and others snakes' tongues [...] If the flood was by rain that swelled the rivers or by the rising of the sea, [...] the niches, as a heavy matter, are not pushed from the sea to the mountains, nor pulled to themselves by the rivers against the course of their waters.* (Leicester Codex, probably written between 1504 and 1510, in particular folio 9 r)



**Fig. 2.2** Fragment from the Leicester Codex, folio 9 r, line nine and the beginning of the tenth. The sentence has been inverted horizontally to be legible according to common usage (modified) (Public Domain)

These Leonardian considerations, like many other of his observations and studies, did not spread much because they were unknown or little known among his contemporaries and had no influence on the establishment of paleontology, from his time to the second half of the nineteenth century when the codices were found. Nevertheless, it seems that similar ideas, as well as Galilean teachings, somehow circulated in Roman cultural circles in the first half of the seventeenth century at the time frequented by the Messina painter Agostino Scilla, who will be influenced, at least for the method of analysis adopted, in the drafting of his treatise, *La Vana speculazione disingannata dal senso* (Giallombardo 2016: pp. 37–38).

Because of the following that it had on his contemporaries and later scholars, the most accredited explanation of the term *fossilia*, with the indication among them of the remains of ancient lithified organisms, even if not recognized as such by the author and therefore believed to be nonorganic still following the Aristotelian legacy, is generally attributed to Georg Bauer (or Pauer) (1495–1555), also known by the Latinized name of Georgius Agricola, a German scientist considered the father of mineralogy:

*Quelle cose fossili poi, che ò sono un rimedio, et una medicina al corpo; ò che l'affliggono e tormentano; prendendosi ò col mangiare, ò col bere; ben che anche esse patiscano, hanno nondimeno una segnalata virtù e potentia di fare. Ma quelle, che sono un rimedio al corpo, il curano parte per le loro proprietà, che hanno in tutto l'essere lor: parte per qualche qualità, che cagiona la sanità. Di quelle che per la proprietà vagliono; alcune repugnano, et ostano à i veleni; alcune altre ne guariscono i morbi [...] Altre che vanno a finire à guisa di turbine, sono torte, come lumache; la qual figura in alcune pietre si vede [...] Alcune hanno d'ogni parte un certo che sporto in fuori, come un porro; come è la Mirmecia. Altre rappresentano figure di altre cose; come il corno di Ammon rappresenta il corno; il Tephrite mostra la effigie d'una nuova luna cornuta [...] Pare un core di bue, la bucardia [...] rappresentano figura di lenticchia, la arena de l'Aphrica; et alcune pietruzze presso le piramidi de l'Egitto; et in un colle della Cappadocia. Di più; lo stelechite è simile à un tronco d'albero: il belemnite, à una saetta; la gemma che chiamano chalazia; à un grandine: la pietra giudaica, à la ghianda. (Tramezzino 1550)*

*Those fossil things, then, which are either a remedy or a medicine for the body, or which afflict and torment it, whether by eating or drinking, although they may also suffer, nevertheless have the virtue and power to do so. But those which are a remedy for the body cure it partly by their properties, which they have in their whole being: partly by some quality which causes health. Of those that are useful for their properties, some repel and resist poisons; some others heal diseases [...] Others that end up like a whirlwind, are twisted, like snails; which figure can be seen in some stones [...] Some have a certain protruding outward, like a leek, like Myrmecia. Others represent figures of other things; as the horn of Ammon represents the horn; the Tephrite shows the effigy of a new horned moon [...] It seems an ox hearth, the bucardia [...] represent the figure of lentil, the sands of Africa; and some pebbles near the pyramids of Egypt; and in a hill of Cappadocia. Moreover; the stelechite is similar to a tree trunk: the belemnite, to a thunderbolt; the gem they call chalazia, to a hailstone: the Judaic stone, to the acorn. (Tramezzino 1550)*

Moreover, Agricola expresses his own idea of the meaning of *fossilia*, which is of excavated things (*fossor* is the Latin etymon corresponding to our *digger*) concluding that under this denomination are included those bodies whose constituent substances can be traced back to earth, stone, and metal, summarizing everything in a synoptic table (Fig. 2.3):



Fig. 2.3 Tramezzino Michele (De la natura de le cose fossili, 1550: 185v). The subdivision of *fossilia* proposed by Agricola [<https://archive.org/details/hin-wel-all-00002012-001> (not copy-right found)]

*Ma perché si faccia questa dottrina più piana e più chiara, mostrerò quali siano quelle cose, che sono prime e più generali in questa materia, e che complettono tutte le cose fossili. Ma quante e quali queste si siano, non vi si trovano gli scrittori concordi: perché (come Aristotele ci insegna) sono due le spetie de' corpi, che dentro la terra si generano; cio è i fossili, che egli chiama ne la lingua sua Oriciti: e quelli, onde i metalli si generano, che egli metallenti chiama. [...] Ma ò che Aristotele seguisse questa comune usanza di parlare, ò pure che per altra cagione questa distensione si facesse; egli non avertì che ogni materia, onde i metalli si fanno: non è meno fossile, che le terre di pregio, e le pietre si siano: il che essendo così come io dico; assai chiaro si vede, che il corpo fossile è più generale, e comprende in se la terra, la pietra, il metallo. (Tramezzino 1550)*

*But in order that this doctrine may be made easier and clearer, I will show which are the first and most general things in this matter, and which include all things fossil. But there is no consensus among writers as to how many of these things there are, because (as Aristotle teaches us) there are two types of bodies that are generated in the earth, namely, fossils, which he calls in his language Oriciti, and those from which metals are generated, which he calls metallenti. [...] But whether Aristotle followed this common custom of speaking, or whether for some other reason this distinction was made, he did not say that every matter, from which metals are made, is no less fossil than valuable earth and stones are: which, being so as I say; is very clear that the fossil body is more general, and includes in itself earth, stone and metal. (Tramezzino 1550)*

As it is clear from Agricola's explanatory text and from the proposed scheme, the broader category of *fossilia*, i.e., inanimate underground bodies, therefore all-inclusive, is divided into subcategories, among which, at the last level of the scheme, there is a grouping including stone, gem, marble, and rock, but without any reference to petrous bodies in the shape of animate things, which would have allowed us

to recognize fossils as we understand them today, even though they are indicated in some way in the text, as in the passage above. For greater clarity, therefore, we point out that conceptually Agricola's fossils are not the *fossils* as we understand them today, even if they are unconsciously contained in them. Archaeological finds were also included in these categories of unearthed materials and are sometimes depicted in the same publication together with natural things, as did, for example, Gessner and Aldrovandi. For a more detailed discussion of Agricola's contribution, see Nicoletta Morello (Vai and Caldwell 2006).

Many scholars believe that the Protestant Swiss physician and naturalist Conrad Gessner (1516–1565) of Zurich, Switzerland, has the merit of explicating *fossilia* in his writings and numerous illustrations, including those of animal and plant remains. Considered by many to be the greatest naturalist of his century and a forerunner of paleontology, he would acquire this merit in his last literary work *De omni rerum fossilium genere* (1565). This work dedicated entirely to this set of petrous objects, although a prodrome to a larger, though never finished and published, due to the death of the author, plays an important role in the development of the study of *fossilia* to fossils; Gessner's book introduced several innovations that will be taken up by his contemporaries and subsequent writers, although they were included in the *Index Librorum Prohibitorum*, a list of works prohibited for the content deemed wholly or partly prohibited, drawn up by the Roman Church in the fight against heresies.

If it is true that other texts already existed that dealt with these stone bodies, and some of the names used can be found in the works of classical authors up to medieval lapidaries, Gessner's book is the first in which the illustrations are used systematically. In addition, the names of *fossils* are written not only in Latin but also in Greek and German, in order to expand the knowledge and facilitate the recognition. Also the already mentioned, Agricola deals with these topics, but the absence of illustrations made then difficult the identification of the objects he was describing. Another new element found in Gessner's treatise is the encyclopedic approach with which, while acknowledging the value of the ancients, he emphasizes personal and direct observation of nature. These two aspects form the basis for another innovation contained in this book, the direct reference to a personal collection of artifacts, considered the first collection of these natural objects according to today's concept, that of his friend Johann Kentmann (1518–1574) (Fig. 2.4).



**Fig. 2.4** On the left, a portrait of Georg Bauer, the *Georgius Agricola* of the Latins and, on the right, a portrait of Konrad Gesner, or Conrad Gessner, his Latinized name being *Conradus Gesnerus*. [Modified after <https://babel.hathitrust.org/cgi/pt?id=gri.ark:/13960/t0dv92j6f&view=lup&seq=8> (Public Domain)]

Obviously the question of fossils could not be separated from the hypotheses on the layers in which they were found and the origin of the earth's crust, so the dominant intent, in addition to classify them, was to explain a fundamental characteristic of these objects, the petrification, the being of stone, and their mode of formation. Other sixteenth-century authors, important for having given their contribution to the dispute about the nature of fossils and other natural phenomena such as the origin of earthquakes, mountains, thermal waters, etc., were Girolamo Fracastoro (~1476–1553), Gerolamo Cardano (1501–1576), Gabriele Falloppio (1523–1562), and Andrea Cesalpino (1519–1603), in whose books on these subjects, however, illustrations of fossils are absent.

In Renaissance treatises, in the Latin West, the Greek term *Orycta* was replaced by the Latin term *fossilia*, a substitution then due not to a different meaning of the definitions but to the different language used.

It is above all in Italy that during the course of the sixteenth century, these new currents of thought took shape, later spreading throughout Europe, which would later prove to be fundamental for the development of the science called natural history. Also during the Renaissance, the interest in spices, essences and plants in general, led to the founding of the first botanical gardens and an increase in studies on medicine, famous among the authors who dealt with it, the Sienese Pietro Andrea Mattioli who translated into Italian Dioscorides' *De Materia Medica*, published for the first time in 1544 in Venice. Some fossils were also occasionally used as ingredients in the pharmacopoeia of the time (Mattioli, 1548). This climate of new awareness and attention obtained through new knowledge acquired also personally through direct experience and observation, tending to fill the gaps inherited from the authors of the past, continued in the first half of the seventeenth century where numerous naturalistic works were produced, such as monographs, encyclopedias,

and descriptions of collections and museums, even if a general and unified nomenclature had not yet been achieved:

*In this century the systematic division of petrified shells into genera and species was not yet known. From the time of Mercati the names conchites, ostracite, ceramite, ctenite, muricite, buccinite, dentalite, strombite, cochlite and ammonite, of which Pliny had made use, were known and in use, but without any proper classification, so that petrified shells were well placed among the fossils, but were as much among the class of idiomorphic stones as in that of figured stones and sometimes in another. The particular species of petrified shells were not then examined more closely, as was done in the following century. (Walch 1768–1773: p. 21)*

To the process of circulation of ideas in general, and on fossils in particular, contributed in an obvious way the introduction of printing with movable type that allowed a more rapid spread of writings through printed volumes, in greater quantities and at lower costs, first without illustrations and then more and more richly illustrated, to consider the reproduction of the image almost more important than the description. In the first prints, the fossils are reproduced in a rather inaccurate, sometimes banal way, despite the fact that in the Renaissance, the figurative and pictorial arts were at a very high level of quality and expression. In the following seventeenth-century naturalistic studies benefited from more accurate illustrations which, together with the first true ideas about the formation of fossils, allowed research to continue for further investigation which was fully developed in the following century.

In the 1600s, iconography became an indispensable part of the text, a new practice of communication between writers and readers, an indispensable visual support for correctly identifying what had previously been handed down in the form of names, which often became increasingly obscure and indecipherable as the translations and copies of the oldest texts changed hands, or the countless natural finds hitherto unknown, from the “new worlds” discovered with the expansionist, commercial, and even naturalistic explorations that multiplied from the discovery of the Americas. This figurative mode with illustrations of remarkable quality and precision, even colored by hand, was widely used in herbaria, for example, making it easy to recognize the plants from which the natural principles were extracted, essential ingredients in medical preparations and sources of considerable earnings. Perhaps the most striking example of this new way of representation, and at the same time of visual cataloguing, is the so-called *Museo Cartaceo* edited by Cassiano dal Pozzo (1588–1657), a vast collection of drawings and prints, put together with the intention of creating a sort of encyclopedia of ancient and natural things, such as landscapes of ancient Rome, archaeological remains, animals, plants, minerals, and fossils.

The years between the sixteenth and seventeenth centuries are therefore crucial for the development of earth sciences. Those who contributed most to the scientific debate through their works, simple treatises, or real encyclopedic collections, on the *quaestio de fossilibus*, were mainly the already mentioned Agricola and Gessner, the Bolognese Ulisse Aldrovandi (1522–1605), the Neapolitan Ferrante Imperato (1550–1631) and Fabio Colonna (1567–1640), the Dane Niels Stensen, Italianized