Title: Life as a palaeontologist: Palaeontology for dummies, Part 2

Author(s): Russell Garwood *1

Volume: 4
Article: 2
Page(s): 1-10
Published Date: 01/02/2014
PermaLink:
http://www.palaeontologyonline.com/articles/2014/life-as-a-palaeontologist-palaeontology-for-dummies-part-2

CITATION OF ARTICLE

Please cite the following published work as:

Garwood, Russell. 2014. Life as a palaeontologist: Palaeontology for dummies, Part 2, Palaeontology Online, Volume 4, Article 2, 1-10.

Published by: Palaeontology [online]

Life as a Palaeontologist: Palaeontology for dummies, Part 2

by Russell Garwood*1

Introduction

In *Palaeontology for Dummies, Part 1*, we looked at modern palaeontology as a discipline, including the broad range of specialisms in the field. I hope it convinced you that palaeontology is an exciting and ever-expanding subject. Here, in the second part, we will focus on the birth and historical development of palaeontology, which has at times been highly controversial. We'll first consider how humans and fossils interacted before science was formalized, then we will move on to the birth of palaeontology during the Enlightenment era in the seventeenth and eighteenth centuries. We will cover the field's expansion and rapid development during the nineteenth century, and finish with a few of the most notable findings trends in the past century. For sake of brevity, we will have to skip over a lot of important people, as well as many interesting, absorbing and just plain cool stories and innovations. Sorry. Nevertheless, this article will hopefully provide an interesting overview of the history of human interactions with fossils.

Before palaeontology

Palaeontology became established as a science relatively recently, in the past 300 years. Human interactions with fossils run much deeper than this, however: discoveries in caves show us that, for example, trilobites were collected and drilled for use as pendants by early European humans in the late Palaeolithic age (50,000–10,000 years ago, Fig. 1). The same goes for a wide range of other fossils, and the shells or teeth of extinct animals are also sometimes found as grave goods in Bronze Age human burial sites. We assume that these fossil encounters had some symbolic or cultural significance for early humans, rather than holding any meaning that we could think of as 'scientific'. Certainly, we have no evidence that fossils were anything but decorative to early humans. The earliest people who left evidence that they had contemplated the origin and meaning of fossils were the Ancient Greeks and their contemporaries. The philosopher Xenophanes of Colophon (c. 570–475 BC) and the historian Xanthus of Lydia (fifth century BC, in what is now Turkey) are both thought to have realized that the presence of fossil shells suggested that the host rocks had originated in the sea. The historian Herodotus (c. 484–425 BC) is thought to have been describing fossilized mammal bones when he spoke of remains in the Mokattam mountains of Arabia that he thought might have belonged to winged serpents. The doctor Hippocrates (460–357 BC) was, in addition to being the father of classical Western medicine, a fossil collector.

Not long after Hippocrates, an intriguing, and surprisingly persistent, relationship between humans and fossils developed: the use of palaeontological artefacts as medicine. The Roman author and naturalist Pliny the Elder says that this practice was common by the first century AD, and it could have been established as early as the time of the Greek natural philosopher Theophrastus (372–287 BC). Medicinal fossils (Fig. 1) included echinoid spines, which were known as *lapides Judaici* (Jews' stones) and were sucked or powdered and taken to treat renal conditions including bladder stones; fossilized fish teeth, usually from the Jurassic period (200 million to 146 million years ago), which were called toad stones and used to treat many diseases and as an anti-venom; and amber, which has been used to counter ailments including gonorrhoea, mental illness, vertigo and the plague. Such treatments continued until well into the eighteenth century.

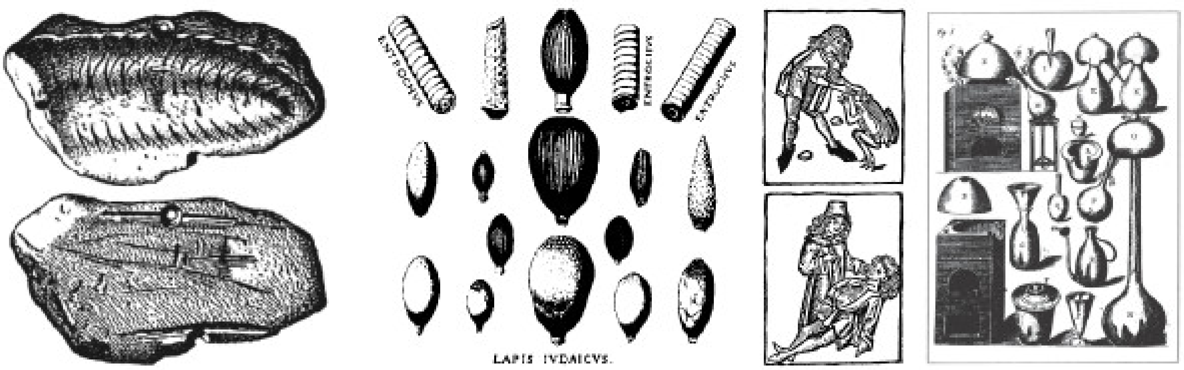

Figure 1 — Left: A trilobite, drilled for use as a pendant and found in France, associated with 15,000-year-old artefacts [Source: St. John, J. 2007. The earliest trilobite research (antiquity to the 1820s). In Mikulic, D.G., Landing, E. & Kluessendorf, J. (eds), *Fabulous Fossils. 300 Years of Worldwide Research on Trilobites*. New York State Museum Bulletin, 507, 201–211.] Middle Left: Diagram showing Jews' stones and crinoid stems from a 1719 work of M. Mercati (Samminiatensis Metal-lotheca. Opus Posthumum, Auctoritate, & Munificentia Clementis Undecimi Pontificis Maximi E tenebris in lucem eductum; Opera autem, & studio Joannis Mariae Lancisii Archiatri Pontificii Illustratum. Cui Accessit Appendix cum XIX. Recens Inventis Iconibus.) Middle Right: An illustration from 1497 (by Johannes de Cuba) showing the extraction and use of a toadstone. Right: Equipment used for processing amber for medicinal uses from a 1678 book by Charras, M. (*The Royal Pharmacopoea, Galenical and Chymical, According to the practice Of the Most Eminent and Learned Physitians of France, And Publish'd with their several Approbations*).

Records of contact with fossils remained scarce for many hundreds of years. Chinese philosopher Li Tao-Yuan (c. 470–527 AD) mentioned fossilized 'stone fishes', and *The Book of Healing* (1027 AD) by Persian polymath Ibn Sīnā (c. 980–1037 AD, Fig. 2), commonly known in the West as Avicenna, suggested that fossils resulted from the action of petrifying fluids, an idea propagated by the philosopher Albert of Saxony (c.1320–1390). However, elsewhere in the world, and certainly for the majority of European scholars from the middle of the first millennium AD until the 'Age of Reason' in the eighteenth century, fossils were seen as antediluvian relicts that had been transported and then buried by the biblical flood. For example, the fossil giant salamander *Andrias scheuchzeri* was described by Swiss scholar Johann Scheuchzer (1672–1733) as *Homo diluvii testis*, a man that had drowned in the flood (Fig. 2). Not everyone thought in this way — Leonardo da Vinci (1452–1519) recorded in his notebooks that fossils were the remains of once-living organisms. In the seventeenth century, and into the Enlightenment, developments in the scientific method and technology, coupled with the gradual emergence of scientific organizations (for example, the Royal Society in London), meant that traditional views began to be challenged. The natural philosopher Robert Hooke (1635–1703) concluded in his seminal work on microscopy, *Micrographia*, that dead wood acted on by water could be preserved as stone, and the Danish bishop and geologist Niels Stensen (also known as Nicholas Steno; 1638–1686) recognized that what had previously been called tongue stones were in fact fossil shark teeth, and that fossils could tell you something about the environment in which a rock had been laid down. Such views, however, were relatively few and far between.

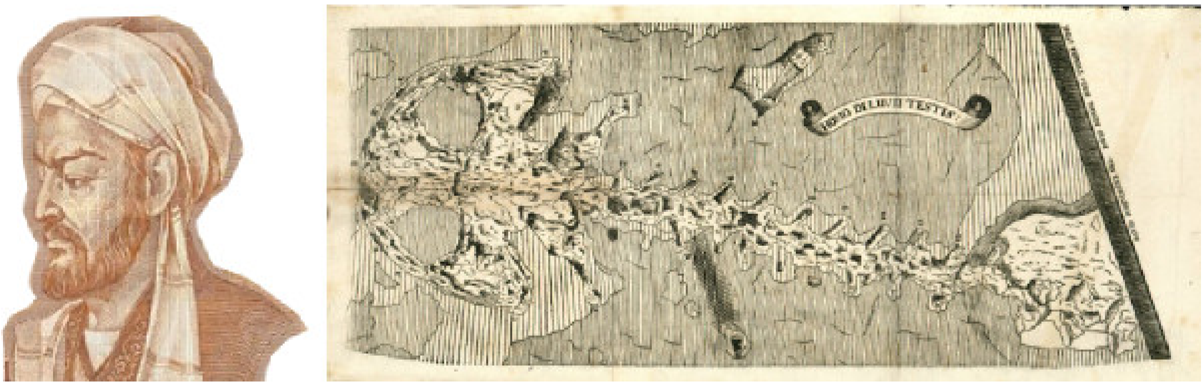

Figure 2 — Left: Ibn Sīnā, who suggested that fossils resulted from the action of petrifying fluids. Right: Johann Scheuchzer's *Homo diluvii testis*, which he suggested was a man that had drowned in the Noachian flood, now known to be a fossil giant salamander.

The birth of a discipline

As such advances started to gain momentum, palaeontology began to be recognized as a scientific field in its own right. French polymath George Louis Leclerc, Comte de Buffon (1707–1788) argued that Earth was more ancient than described in the Bible, and his speculation included early evolutionary ideas and the possibility of extinctions. This long-term view of Earth — which incorporated evidence from rocks — made him an important contributor to early geology and palaeontology, although like many from the era, his theories have not survived the test of time.

Figure 3 — Left: George Louis Leclerc, Comte de Buffon, who argued for an ancient earth. Left middle: William Smith, who created the first geological map of the UK. Middle right: French naturalist Georges Cuvier, instrumental in establishing both palaeontology and comparative anatomy. Right: Jean Baptiste Lamarck, another French naturalist, best remembered for his theory of evolution.

Mining engineer William Smith (1769–1839) made extensive use of fossils when constructing the first geological map of the United Kingdom at the start of the nineteenth century. He is usually considered the founder of biostratigraphy, a field introduced in Part 1, because he used fossil assemblages to correlate formations at different locations. The sites were in very different parts of the country, but Smith had unparalleled access to rock formations because of his work surveying mines and canals. The idea that particular characteristic species or groups of species were limited to particular layers of rock, and could be used to identify and correlate these layers, was crucial. The same concept was germinating across the channel in the work of naturalist Georges Cuvier (1769–1832), geologist Jean-André Deluc (1727–1817) and zoologist Alexandre Brongniart (1770–1847). Soon afterwards, English geologist Henry Thomas De la Beche (1796–1855) showed that a particular mollusc dating to the Eocene epoch (56 million to 34 million years ago) could be found in the London Clay, the Paris Basin and Jamaica; in the process, he demonstrated that biostratigraphy could work across continents.

In addition to his mapping work, Cuvier was instrumental in founding the fields of comparative anatomy and vertebrate palaeontology. By comparing living forms with extinct ones, he established that extinctions had occurred. He placed fossils into the Linnean taxonomic system, and worked on the biostratigraphy of the Paris Basin with Brongniart. He also suggested that reptiles had once been more dominant than mammals, and that the history of life showed evidence of a series of successive ‘creations’ after catastrophic extinction events, bringing him into opposition with his countryman Jean Baptiste Lamarck (1744–1829). Lamarck’s concept of evolution, which famously included the inheritance of characteristics acquired in life, looked at things in a slower and more measured light, and was an early example of evolution viewed as being the result of natural laws. This important advance, coupled with his work systematizing the invertebrates, makes Lamarck’s impact on the development of palaeontology especially notable.

Establishment

At this point we have to start missing out large chunks of history and focus on a few select appearances so that this article does not turn into an epic saga. We start with Britain’s Mary Anning (1799–1847; Fig. 4), who was instrumental in the development of palaeontology through her discovery of a wide range of Jurassic fossils near her home town of Lyme Regis in Dorset. The fossils included marine ichthyosaurs and plesiosaurs, a flying pterosaur, and important fossil fish. The famous painting and print *Duria Antiquior* (‘A more ancient Dorset’; Fig 4), painted by De la Beche, was heavily influenced by her discoveries.

Figure 4 — Left: Mary Anning and her dog in a portrait pre-dating 1833. Middle: Letter from Mary Anning showing a newly discovered fossil (the species later described as *Plesiosaurus dolichodeirus*) from boxing day 1823. Right: *Duria Antiquior*, a painting by Henry De la Beche based on the fossils of Mary Anning.

Around the same time, biologist Richard Owen (1804–1892) was responsible for inventing the name dinosaur; he also established London's Natural History Museum and made that institution accessible to the public. He was a comparative anatomist with notably diverse interests, who is also remembered as a controversial character, opposing Charles Darwin's theory of evolution (at least by means of natural selection) and maintaining numerous professional feuds, in part because of a habit of claiming the credit for other people's work. Owen also oversaw the building of life-size dinosaur reconstructions created for and after the Great Exhibition of 1851 (Fig 5), which can now be found in London's Crystal Palace Park.

FIGURE 5 — LEFT: RICHARD OWEN AS A YOUNG MAN. MIDDLE: THE CRYSTAL PALACE DINOSAUR MODEL BEING CONSTRUCTED IN THE SYDENHAM STUDIO OF BENJAMIN WATERHOUSE HAWKINS. RIGHT: ONE OF THE MODELS TODAY.

One of Owen's contemporaries was Gideon Algernon Mantell (1790–1852), an obstetrician and palaeontologist. In part inspired by the discoveries of Mary Anning, he found and became the first to document the teeth of a dinosaur. His colleagues were slow to accept his ideas, but Mantell eventually overcame their inertia and convinced them of the reptilian nature and age of these Mesozoic Era (251 million to 65.5 million years ago) fossils, which he named *Iguanadon*. His story was not a happy one, however: it ended with extreme poverty, a crippling coach accident and a fatal opium overdose.

The origins of the geological column — which includes the fossil assemblages that can be used across the globe to date rocks relative to each other — also lie in this period. The first person to work on the idea was William Smith, but the construction of the first formal chronology of rocks was a major undertaking involving many scientists, and was a massive achievement for the nascent palaeontological community. Early endeavours focused on the lower Palaeozoic Era (542 million to 251 million years ago); in particular, the Cambrian, Ordovician, and Silurian periods were established early on the basis of Welsh rocks. UK geologists Roderick Impey Murchison (1792–1871) and Adam Sedgwick (1785–1873) began work on rocks of this age in 1831, and published their findings in 1835. Murchison attached great importance to fossils when studying rocks, but Sedgwick paid more attention to the sedimentology of the rock units. Each wanted the honour of describing these early rocks, and Murchison's definition of the Silurian overlapped with Sedgwick's definition of the Cambrian, leading to a long-standing feud — resolved only through the work of Charles Lapworth (1842–1920), who neatly defined the overlap as the Ordovician. Similarly, the establishment of the Devonian period was a tussle between 'team Murchison/Sedgwick', before their estrangement, and De la Beche, who believed that the Silurian should segue directly into the Carboniferous (a distinctive period identified early, in the early 1820s, due to its abundant coal deposits). The former won. John Phillips (1800–1874), an English geologist, published the first global timescale in 1841, splitting the Phanaerozoic eon (541 million years ago to the current day) into its now familiar three sub-divisions: the Palaeozoic, Mesozoic and Caenozoic eras. The Scottish geologist Charles Lyell (1797–1875), in addition to working on the more recent end of the geological timescale, at the time called the Tertiary period, recognized that the older they are, the less fossils resemble modern communities. He suggested that such differences could be used to date rocks.

Figure 6 — Left: Gideon Algernon Mantell as a young man. Left Middle: Adam Sedgwick in 1832. Right Middle: Charles Lapworth, painted around the turn of the 20th century. Right: Charles Lyell at the British Association meeting in Glasgow, 1840.

Evolution and the bone wars

Charles Darwin (1809–1882; Fig. 7) was heavily influenced by geology. He took a copy of Lyell's 1830 book *Principles of Geology* with him on his trip round the world on the *HMS Beagle*; when he returned to the United Kingdom, the famous scholars started what became a life-long friendship. When the theory of evolution through natural selection was outlined by Darwin and Alfred Russel Wallace (1823–1913) in 1858, neither author put particular weight on the fossil record. A year later, in *On the Origin of Species*, Darwin highlighted the reason for the omission in a chapter titled 'On the Imperfection of the Geological Record'. The fossil record was too sparse, he posited, to show intermediate varieties between species. Following the publication of Darwin's seminal work, his contemporaries worked frantically to find forms that were intermediate between other species, and since the late nineteenth century, palaeontologists and biologists have recognized fossils as a singular resource for directly observing the patterns and processes of evolution. Hence, the theory of evolution has impacted palaeontology greatly — transforming it from a means of correlating rocks to a resource for understanding other processes. This gradual broadening of scope continues to this day. Fossils are now being used to inform questions and research programmes on which they had previously been silent.

By the mid-nineteenth century, palaeontology was an established and fashionable discipline: perhaps its popularity then is one of the reasons that today it is sometimes stereotyped as an old, even anachronistic, discipline. Towards the end of the nineteenth century, vertebrate palaeontology began to shift from being a largely European pursuit to one most active in North America, where rich bone beds were discovered in states including Colorado, Nebraska and Wyoming. A particularly heated rivalry, dubbed the Bone Wars, developed between Edward Drinker Cope (1840–1897) and

Othniel Charles Marsh (1831–1899). Both gentlemen (Fig. 7) possessed strong personalities, and, despite initially getting along, fell out towards the end of the 1860s. Starting in 1872, and hitting a peak between 1877 and 1892, the pair embarked on a huge number of expeditions to collect Mesozoic and Caenozoic vertebrate fossils, and used their funds and influence to acquire fossils by any means necessary — moral or otherwise. Over the course of their careers they established more than 140 new species between them, and went to great efforts to discredit each other, culminating in a series of articles and responses in newspapers including the *New York Herald*. These publicly aired grievances that had previously been an open secret limited to the palaeontology community. Cope accused Marsh of financial mismanagement and plagiarism, and Marsh responded by accusing Cope of slander, branding him a liar and a thief. *The Philadelphia Inquirer* ran a piece suggesting that Cope provide proof or quit – but ultimately newspapers lost interest, and the story fizzled out. The Bone Wars was a colourful episode in the history of palaeontology, but also one with an enduring scientific legacy. Many of the finds, despite the vitriol of Marsh and Cope, were of great importance: genera named by the two include *Triceratops*, *Allosaurus*, *Diplodocus* and *Stegosaurus*.

FIGURE 7 — LEFT: DARWIN AROUND THE TIME HE WENT ON THE VOYAGE OF THE *BEAGLE*. MIDDLE: OTHNIEL CHARLES MARSH. RIGHT: EDWARD DRINKER COPE.

Twentieth-century developments

"There is no period so remote as the recent past," said the teacher Irwin in Alan Bennett's *The History Boys*. There's an element of truth to this; coupled with the ever-increasing breadth of palaeontology and its subdisciplines, this makes highlighting particular people or innovations very difficult. It is possible, nevertheless, to pick out some noteworthy trends. Last century saw the world of palaeontology diversify greatly. The plethora of overlaps with other areas (see *Part 1*) began to develop as palaeontologists collaborated more and more with workers outside their fields. Indeed, during this time non-palaeontologists — well, people who had initially trained in other fields — also started using fossils to say interesting things. Early in the century, studies began to get a lot more biological in nature. The term palaeobiology was coined for this increasing focus on the physiological and biological, rather than geological, importance of fossils. The discovery of DNA, followed by a growing number of uses for studying life, have further linked biological sciences to the fossil record. Examples include the development of DNA-based evolutionary trees, the extraction of ancient DNA and molecular dating. The techniques used to study fossils have developed too, greatly affecting palaeontology as a field. Over the past century, geochemistry and associated instrumentation has come into its own and given us the ability to place absolute dates on rocks, provide an idea of the palaeoenvironments in which creatures lived, and probe the preservation of fossils. This has been integral to the establishment of taphonomy, the study of the preservation of fossils, as a field. The advent of readily accessible computing power has allowed palaeontologists to do everything from cladistics (working out the evolutionary relationships between species using a computer) to creating databases of fossils that help to answer questions about the geographical distribution of groups through earth history. Electron microscopes, developed in the 1930s, allowed fossils to be explored at much higher resolution than light microscopy, greatly aiding the development of micropalaeontology.

FIGURE 8 — LEFT: FOSSIL ARTHROPOD FROM THE CHINESE CAMBRIAN CHENGJIANG DEPOSIT (IMAGE COPYRIGHT CHENGJIANG FOSSIL NATIONAL GEOPARK MANAGEMENT). RIGHT: INSECT FOSSIL FROM THE LOWER CRETACEOUS BRAZILIAN SANTANA FORMATION.

The past century has also seen palaeontology probe deeper into the past, looking at the fossil record from the Precambrian eon, the time before the rapid diversification of life about 541 million years ago. A number of groups have focused on the study of particular Lagerstätten, or deposits of sedimentary rocks with exceptionally preserved fossils, and have increased our knowledge of life from the age in which the rocks were laid down. In the Precambrian, this includes the Australian Ediacara Hills and the Chinese Doushantuo Formation; the Cambrian is studied through the Canadian Burgess Shale and, in the past 30 years, the Chinese early Cambrian Chengjiang deposit. The rest of the Palaeozoic has yielded sites including the Ordovician Soom shale (South Africa); the Devonian Rhynie Chert (Scotland), Hunsrück Shale (Germany) and Gogo Formation (Australia); and the Carboniferous Mazon Creek (United States). Mesozoic Lagerstätten include Ghost Ranch (United States), the Solnhofen Limestone (Germany) and the Crato/Santana Formations (Brazil). The study of fossils through time has also been used to aid both geological advances such as the recognition of plate tectonics, and biological hypotheses such as punctuated equilibrium (introduced here). Palaeontology is still developing, and it is a very exciting time to be involved in the subject.

Conclusion

Palaeontology has deep roots: humans have recognized that there is something special about fossils pretty much as far back as history can tell us. For a long time, fossils attracted supernatural explanations, such as magic and Noah's flood. The history of palaeontology after these ideas were abandoned reflects changes in the Western world, where much of its early development occurred. Through the eighteenth century, palaeontology became established as natural philosophers shunned supernatural explanations in favour of empirical ones. This move marked the beginning of palaeontology as a scientific discipline, and was followed by an ever-increasing number of palaeontological works — many by gentlemen scientists — as the nineteenth century progressed. With the development of the theory of evolution, it became clear that palaeontology could help to answer big questions, and the late nineteenth to twentieth centuries marked a move towards looking at the biology of extinct organisms, rather than just documenting them. The time since has seen palaeontology become an increasingly interdisciplinary field, eventually becoming the cutting-edge and broad field highlighted in *Part 1*. Who knows what the future holds!

Further reading

Duffin, C. J., Moody, R. T. J. & Gardner-Thorpe, C. (eds). 2014. SP375 *A History of Geology and Medicine. The Geological Society* (ISBN: 978-1862393561)

Gould, S. J. 1988. *Time's Arrow, Time's Cycle: Myth and Metaphor in the Discovery of Geological Time (The Jerusalem–Harvard Lectures)*. Harvard University Press. (ISBN: 978-0674891999)

Rudwick, M. J. S. 1985. *The Meaning of Fossils: Episodes in the History of Palaeontology.* University Of Chicago Press, Chicago. (ISBN: 978-0226731032)

---

[1] 1851 Royal Commission Research Fellow | School Of Materials / School of Earth, Atmospheric and Environmental Sciences, The University of Manchester, Oxford Rd., Manchester M13 9PL.