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The Saga of the False Fossil Foram *Eozoon*

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Abstract

Eozoon canadense, 'the dawn animal of Canada', a large foraminifera, was announced in 1864 as the oldest fossil organism known. Camps soon formed into disbelievers of its fossil nature, agnostics, and "Eozoonists". *Eozoon* would number among its proponents major figures of the time. The saga of *Eozoon*, or more precisely the dispute as to its actual nature, spawned hundreds of publications. Here the story is told with a new focus, one on the stature and roles of the major personalities involved, and the evidence they presented. *Eozoon* is considered to have been 'de-bunked' in the late 19th century. However, it will be shown that it was never indisputably proven to be inorganic. Rather *Eozoon* simply faded away after its most ardent defenders died. As late as 1947, it was shown as the primordial organism in a biology textbook. The saga of *Eozoon* remains as a valuable cautionary tale. It is an example of an artifact accepted as fact because it filled a troubling void in knowledge, i.e., at that time, the first traces of life before Cambrian, and it endured because it was promoted by only a few, but powerful, figures in the scientific establishment of the era.

Keywords: History of protistology; foraminifera; William Carpenter; William Dawson; William King; William Logan; Karl Mobius; Precambrian life

Introduction

Stephen J. Gould described *Eozoon canadense*, the alleged first fossil, and *Bathybius*, the alleged primordial life form, as among the great mistakes of biology, but in his opinion, likely less than one of percent of biologists know of either (Gould, 1980). However, as protistologists, many of us know something of both. With regard to *Eozoon canadense*, the name is likely familiar to those who work on foraminifera as the would-be fossil foraminifera now known to be a mineral formation. In 1864 it was formally described as the first animal fossil found in a pre-Cambrian stratum. The 'discovery' of *Eozoon* was just a few years after the appearance of the first edition of *The Origin of the Species* (Darwin, 1859) and *Eozoon* solved a major problem for nascent Darwinism, the lack of any fossil record preceding the Cambrian with its startling diversity of metazoan animal fossils. The absence of pre-Cambrian fossils at that time was known as Darwin's dilemma and *Eozoon* appeared to have solved it (Schopf, 2000). Although little known today, the argument over the nature of *Eozoon*, as fossils or inorganic mineral formations, was one of the greatest scientific controversies of all time involving major personalities of the Victorian Age, and hundreds of publications in both the popular and scientific press. Hoffman's *Precambrian Fossils, Pseudofossils and Problematica in Canada* (Hoffman, 1971) lists a total of 265 *Eozoon* references.

Admittedly, the saga of *Eozoon* is now old, having begun with a burst onto the international scene in 1864, but the story still merits attention today. Long ago, an opinion was put forth by Whitney and Wadsworth (1884) "*For the purpose of accounting, to a certain extent, for the extraordinary delusion which has prevailed among paleontologists with regard to organic nature of Eozoon...*". They attributed the early widespread acceptance of *Eozoon* "*...in part, to the entire ignorance which prevails among many zoologists and paleontologists as to the great variety of forms occurring in the mineral kingdom, which it only requires an imaginative temperament to endow with the attributes of organic structure.*" However, *Eozoon* was enduringly accepted as a fossil, due, not only to ignorance as opined by Whitney & Wadsworth, but perhaps more importantly due to the stature and power of its few proponents. The long life of *Eozoon* was described by Raymond, in his address as retiring president of the Paleontological Society, as a sad example of "*...the general human tendency to play follow the leader*" (Raymond, 1935). Thus, it is worth reviewing today as a cautionary tale.

The story of *Eozoon* has received considerable attention from historians of biology (O'Brien, 1970, Rehbock, 1975, Adelman, 2007). Quite recently, in astrobiology, it was given as a prime example of a '*false microbial biosignature*' to be guarded against in the search for extra-terrestrial life (McMahon & Cosmidis, 2022). However, what all previous accounts of *Eozoon* have omitted are the main

focus of this review: a look at the lives and relative statures of each of the major figures involved, and actual examples of the evidence they presented in support of their views. Here, the saga of *Eozoon* will be told through biographical vignettes of the major figures involved (Fig. 1), along with examples of the evidence each presented to the scientific community (original complete, and often lengthy figure legends, are provided in a supplementary file).

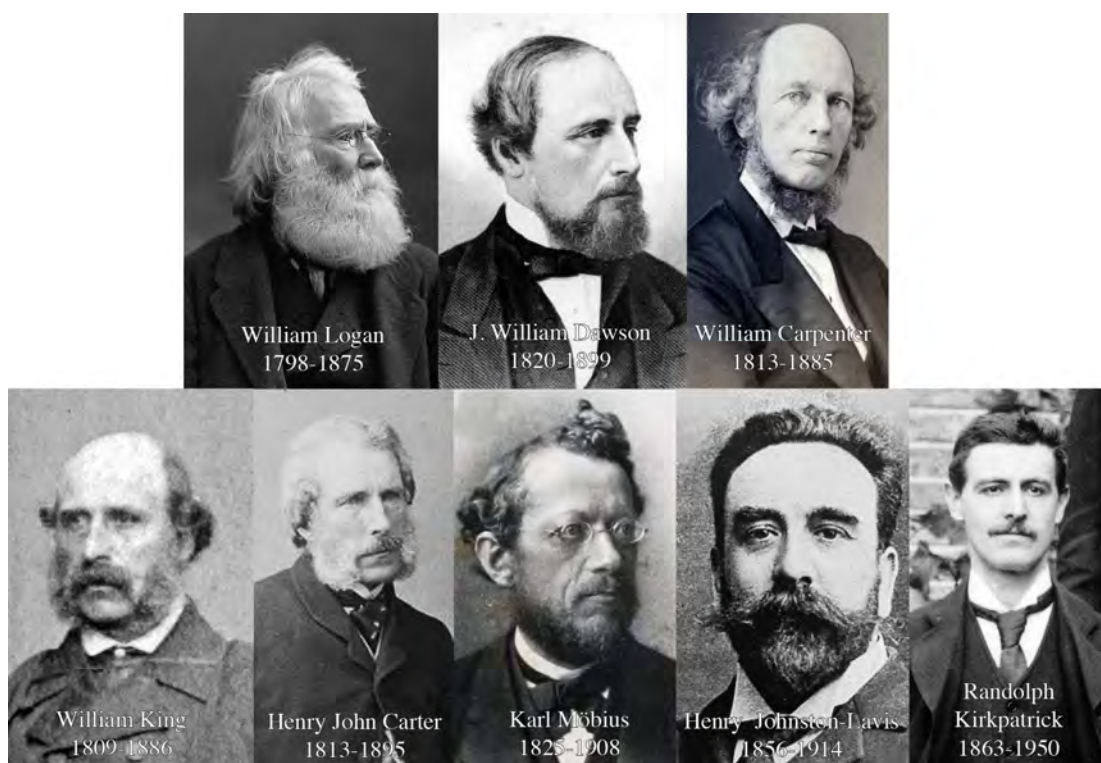


Fig. 1. The major personalities in the saga of *Eozoon*. The top row shows the three principal proponents of *Eozoon*, from left to right, William Logan head of the Canadian Geological Survey, J. William Dawson, the principal of McGill College, and William Carpenter, Registrar of the University of London. The bottom row shows the five principle opponents, from left to right, William King, Professor at Queen's College Galway, Henry Carter, a retired army medical doctor, Karl Möbius, Professor at the University of Kiel, Henry Johnston-Lavis, a physician and geologist, and Randolph Kirkpatrick Assistant at the British Museum.

It will become apparent that there was a great disparity in the scientific and social statures of the proponents and opponents and that the 'evidence' was not at all easy to judge. Finally, it will be shown that despite having been 'disproven', not once but three times in the 19th century, *Eozoon* endured well into the 20th century. The proposition put forward here is that its longevity can be attributed to the influence of the two major proponents of *Eozoon*, William Dawson and William Carpenter. Thus the moral of the story told here, relevant today, is that it behooves one to consider evidence in a scientific contention without any regard as to the stature of the proponents and opponents.

William Logan the one who uncovered *Eozoon*

The following biographical account of Logan is based largely on Harrington (1883) and Winder (2004). William Edmond Logan was born in Montreal, Canada in 1789 into a wealthy family of emigrants from Scotland. At age 16, he was taken back to Scotland to finish High School and he then attended Edinburgh University. He worked first in London for his uncle as a mineral broker, and in 1831 moved to Swansea in Wales to manage his uncle's copper and coal businesses. In Swansea he began his geological studies focusing on the coal deposits. In 1841 Logan obtained a newly created position, Director of the Geological Survey of Canada, and returned to Montreal. In 1851 Logan was elected to the Royal Society of London, the first member from Canada. For his work on mapping the geology of Canada, in 1856 Logan received the Wollaston Medal from the Geological Society of London and was knighted. In 1857 Logan chaired the annual meeting of the American Association for the Advancement of Science held in Montreal. His major work was the monumental *Geology of Canada* published 1863-1865 and Logan was awarded the Royal Gold Medal of the Royal Society of London in 1867.

The saga of *Eozoon* began with Logan. He first spoke of possibly organic remains in the "azoic" Laurentian limestones at the 1859 meeting of the American Association for the advancement of Science (Anon., 1859). In 1863, Logan received an unusual specimen from one of his surveyors. He had it sectioned to determine if it might indicate a marble deposit. Billings, the paleontologist of the Geological Survey, seeing unusual structures, sent slices to William Dawson of McGill College who at that time was one of the few people in the Americas experienced in petrographic microscopy. Dawson declared the laminate structure of the specimens to be the fossilized remains of foraminifera. Logan, in a letter to the *American Journal of Science and Arts* in February 1864, announced the finding by Dawson that the structures indicated "*a Foraminifera growing in large sessile patches after the manner of Carpenteria, but of much greater dimensions....*" and that Dawson had proposed to name the fossil *Eozoon canadense* (Logan, 1864). *Carpenteria* had been described, and named for William Carpenter, just a few years before as a form apparently intermediate between rhizopods and sponges (Grey, 1858).

In August of 1864, Logan traveled to Great Britain, in part to have the maps volume of his *Geology of Canada* printed, and in part to announce the discovery of the pre-Cambrian fossil, which Dawson named *Eozoon canadense*, at the meeting of the British Association for the Advancement of Science in September to be held in Bath. One of his first stops was to visit the eminent geologist Charles Lyell, whom he had known since the 1840's when Lyell visited America. Lyell was that year the President of the British Association for the Advancement of Science and was enthused with Logan's discovery. Lyell touted Logan's discovery

in his President's Address opening the meeting (Lyell, 1864) and announced that specimens of *Eozoon canadense* were to be exhibited by Logan (see Fig. 2). Logan formally presented *Eozoon* in a talk entitled "*On Organic Remains in Laurentian Rocks in Canada*".

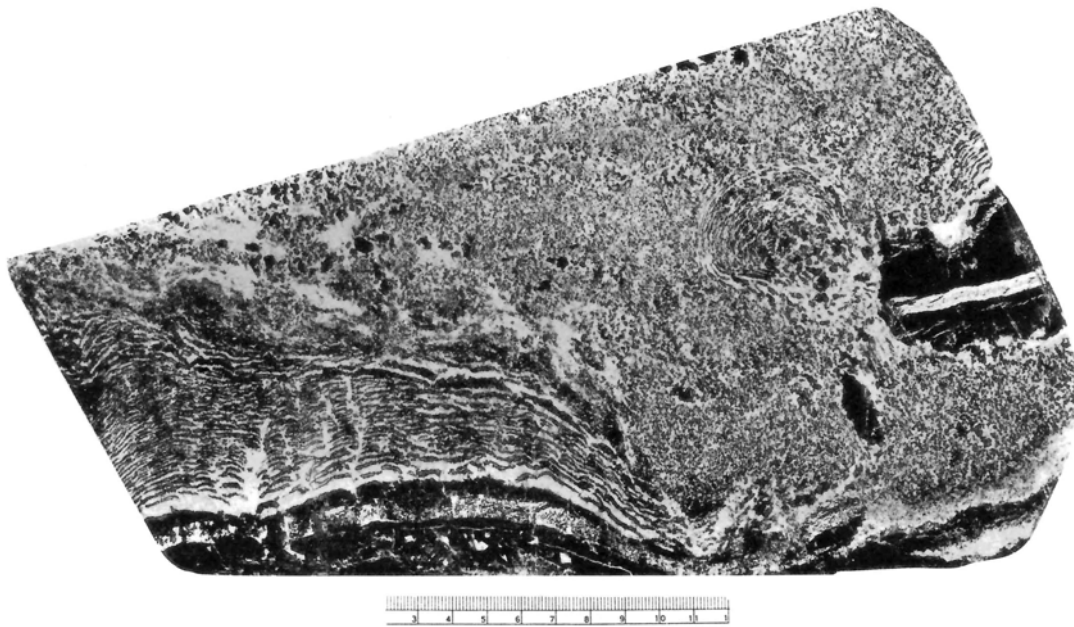


Fig. 2. A specimen of *Eozoon* presumably similar to one shown by Logan at 1864 meeting of the British Association for the Advancement of Science in Bath. The specimen, in the collection of the Geological Survey of Canada (from Hoffman, 1971), shows the laminated structures said by Logan to be fossil remnants of large foraminifera. The ruler shown measures 12 cm. Logan also displayed slides of sections of the specimen. It is unclear whether or not a microscope was available to allow inspections of the slides.

On his return to London after the Bath meeting, Logan presented his findings and showed his specimens to William Carpenter, the foremost authority on foraminifera. Logan had been unable to see him previously due to the ill health of Carpenter. According to Carpenter's biographer (his son), Logan's visit in October 1864 rejuvenated a torpid Carpenter who declared his belief that *Eozoon* was indeed a fossil foraminifera (Carpenter and Carpenter, 1889). In November of 1864, Logan presented his findings and those of Dawson, Carpenter, and Hunt to the Geological Society of London and the presentations were summarized in the January 1865 issue of *The Natural History Review* (Anon., 1865a). The full papers appeared in March of 1865 as a set in the *Quarterly Journal of the Geological Society*: "On the Occurrence of organic remains in the Laurentian Rocks of Canada (Logan, 1865a), "On the structure of organic remains in the Laurentian limestones of Canada" which included a formal species description of *Eozoon canadense* (Dawson, 1865a), "Additional note on the structure and affinities of *Eozoon canadense*" (Carpenter, 1865a), and

"On the mineralogy of certain organic remains from the Laurentian Rocks of Canada" (Hunt, 1865a).

Soon after the four papers were published, accounts of *Eozoon* appeared in the semi-popular and scientific press: in the April Issue of *The Popular Science Review* (Jones, 1865a), in May in *The Intellectual Observer* (Carpenter, 1865b) and in November in *The American Journal of Science and Arts* (Dana, 1865). By June 1865, the first publication contesting the nature of *Eozoon canadense* appeared in *The Reader*, a weekly devoted to science and arts (King & Rowney, 1865a). It would be the first salvo in three remarkable duels of letters and articles between various disbelievers and the two devoted Eozoonists, Dawson and Carpenter. The first was in *The Reader* in 1865, the second in *Nature* from 1870 to 1871 and the last in *The Annals and Magazine of Natural History* in 1874. Despite mounting objections as to the nature of *Eozoon*, the Canadian *Eozoon canadense* was soon joined by the European *E. bavaricum* (Gumbel, 1866) and *E. bohemicum* (Fric, 1869) and the Caribbean *E. caribeum* (Leachmere Guppy, 1870).

Notably, Logan was not a participant in the bitter dispute over the nature of *Eozoon*. Following his contribution to the 1865 set of articles published in *Quarterly Journal of the Geological Society*, Logan published only one article, in 1867, in the *Proceedings of the Geological Society*, on *Eozoon* noting the location where new specimens of *Eozoon* had been found during the explorations of the Geological Survey of Canada. He entirely left the arguments as to the nature of *Eozoon* to Dawson and Carpenter. Logan retired in 1869 and in 1874 returned to Great Britain where he died in 1875. In long obituary notices on Logan published in *Nature* (Giekie, 1875) and in *The Geological Magazine* (Anon., 1875) no mention was made of *Eozoon*, perhaps out of respect for Logan and disrespect for *Eozoon*?

J. William Dawson the one who became *Eozoon's* indefatigable defender

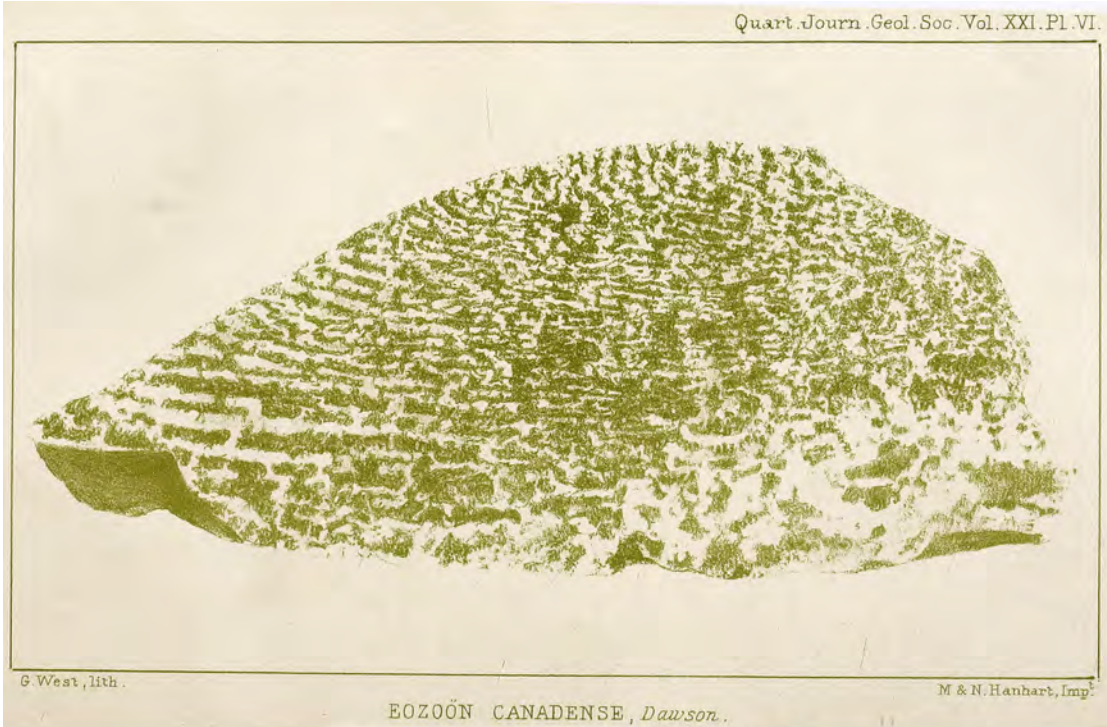
The following biographical account of Dawson is based on Sheets-Pyenson's biography of Dawson (Sheet-Pyenson, 1996), the entry on Dawson in the Dictionary of Canadian Biography (Eakens & Eakens, 1990) and the obituary notices by Adams (Adams, 1899a,b,c). John William Dawson was born in Pictou, Nova Scotia in 1820. His father had emigrated to Canada from Scotland, like Logan's and also like Logan, Dawson studied at the University of Edinburgh. On his return to Pictou, Dawson taught classes in Pictou and in Halifax. He was mentored by Charles Lyell who recommended Dawson for a faculty position at the University of Edinburgh in 1855. Despite Lyell's efforts, Dawson was not offered the position but through the application process he became known as a promising young geologist and friend of Lyell. Shortly after learning that he would not be offered the post in Edinburgh, Dawson was offered the direction of

McGill College in Montreal, and remained at McGill until his retirement in 1893 at age 73. Dawson oversaw the transformation of McGill College into McGill University, one of the major universities in North America. He passed away in 1899, just a few years after his retirement.

Throughout his career Dawson received many honors. He was elected to the Geological Society of London in 1854 and to the Royal Society of London in 1862, sponsored by Charles Lyell and Charles Darwin among others. In 1870, he was awarded the prestigious Bakerian Lecture by the Royal Society of London, and in 1881 was awarded the Lyell Medal of the Geological Society of London. In 1882, Dawson served as the founding President of Royal Society of Canada, and he was knighted in 1884. He served as President of the British Association for the Advancement of Science and presided over the meeting in Montreal in 1886.

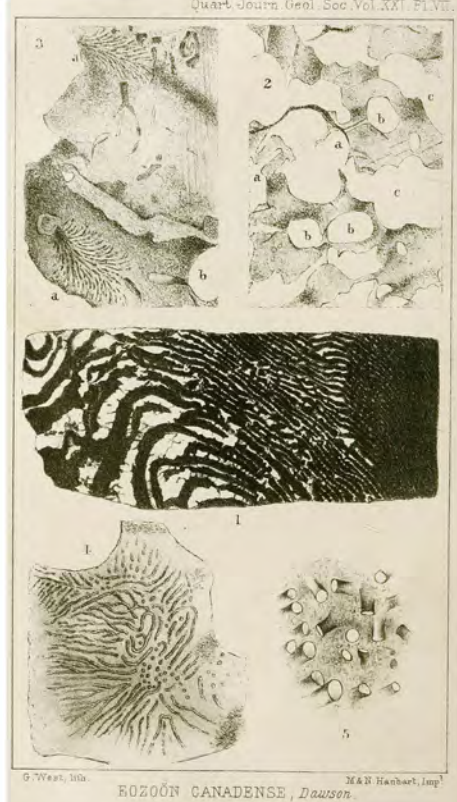
Dawson played the key role in the saga of *Eozoon*. He was the first to examine the microscopic structure of what he named *Eozoon* in sections sent to him from the Geological Survey. According to Dawson's own account, published posthumously (Dawson, 1901), his discovery was not immediate but rather required some effort: "*At first, the specimens seemed to contain no minute organic structure, but at length, in 1864, some carefully selected examples procured from a new locality, showed canals and tubulation, not unlike that found in the shelly covering of the humble marine animals known as foraminifera.*" Dawson had at his disposal some material from William Carpenter, then foremost expert on foraminifera, including "*some slices he had kindly furnished me with*". Dawson had a draftsman make "*enlarged drawings*" and the chemist of the Geological Survey, Hunt, conducted analysis of the chemical nature of the minerals. Dawson urged Logan to present all their notes and materials to Carpenter for expert confirmation when he traveled to Britain in August in Britain. Dawson however did not wait for an expert confirmation. He announced his discovery in May of 1864 in his Address of the President of the Natural History Society of Montreal (Dawson, 1864).

As stated above, Logan found Carpenter unable to receive visitors before October but showed his materials to Lyell in August and gave a talk at the Bath meeting in September. When Carpenter did see the materials Logan brought and Dawson's description, he enthusiastically concurred with Dawson's opinion that that the fossilized remains of a giant foraminifera had been found. Carpenter then provided the note and illustrations (Carpenter, 1865a) published with Dawson's species description of *Eozoon canadense* (Dawson, 1865a). Dawson's illustrations of *Eozoon canadense* from the species description of 1865 are shown in Fig. 3.



EOZOON CANADENSE, Dawson.

Quart. Journ. Geol. Soc. Vol. XXI. Pl. VI.



EOZOON CANADENSE, Dawson.

Fig. 3. The illustrations from Dawson's species description of *Eozoon canadense* from Dawson, 1865a. The top panel show an Eozoon rock, actual size in a flod-out plate, and the bottom plate microscopic structures revealed in various preparations. The complete original figure legends are given in the supplementary file.

As the author of the species description, Dawson was the person most invested in *Eozoon* and whose name was closely associated with it. Hoffman's *Eozoon* bibliography (Hoffman, 1971) lists 62 works authored by Dawson on *Eozoon*. The publications included three books with a major focus on *Eozoon* and pointed responses to critics of *Eozoon*. The first was "*Life's Dawn on Earth Being the History of the Oldest Known Fossil Remains and Their Relations to Geological Time and the Development of the Animal Kingdom*" (Dawson, 1875), the second was "*Specimens of Eozoon and their Geological and Other Relations*" (Dawson, 1888) and the third he published shortly before his death in 1899, "*Relics of Primeval Life: Beginning of Life in the Dawn of Geological Age*" (Dawson, 1897). His obituary notice in *Scientific American* stated that "*His title to fame rests more upon the discovery of the Eozoon Canadense of the Laurentian limestone, the oldest form of animal life, than upon any other discoveries or researches which he made*" (Anon., 1899) and in the obituary notice in *Nature*, Dawson was said to have "*...boldly upheld the animal nature of Eozoon*" (HBW, 1899).

William Carpenter who embraced and defended *Eozoon*

The following account of Carpenter is based on diverse sources: three obituary notices (Lankester 1885; Bonnet 1886; Taylor 1886), the biographical memoir by his son (Carpenter and Carpenter, 1899), and an article on Carpenter by Gardiner (2000). William Benjamin Carpenter was born in 1813 into a family of relatively modest means. His father was a Unitarian Minister and schoolmaster. Carpenter's early education was from his father and mother. He was apprenticed to a medical doctor and then attended medical classes first at the University College in London and then in Edinburgh. He became an M.D. in 1839 and published his first book, an introduction to human physiology. His inspiration for the organization of the book is said to have been the book by Charles Lyell (Dawson's mentor) "*Principles of Geology*" (Lyell, 1830). In 1843, he became a Professor of Physiology in the Royal Institution, and was elected to the Royal Society in 1844. Carpenter served in 1852-1853 as President of the Microscopical Society of London (later the Royal Microscopical Society). In 1856, Carpenter was named Registrar of University College in London. He served as President of the British Association for the Advancement of Science in 1872. Carpenter was named 'BC' (Companion in the Order of Bath) in 1879.

For protistologists, Carpenter's most significant contributions are likely a series of papers he published on foraminifera '*Researches on the Foraminifera*' (Carpenter, 1856a,b, 1859, 1860a), and his book '*Introduction to the Study of Foraminifera*' (Carpenter, 1862). Carpenter was undeniably the foremost expert of foraminifera in his time, as well as an expert on microscopy. His "*The Microscope and Its Revelations*", was the primary microscopy reference work for the latter half of the 19th century. It was first published in 1856 (Carpenter, 1856c) and went through several editions including posthumous 7th and 8th

editions (Carpenter, 1891, 1901). It should also be mentioned that Carpenter is commonly acknowledged as the primary architect of the famous Challenger Expedition of 1873-1876 and only ill-health kept Carpenter from sailing on the *Challenger* himself (e.g., Deacon, 1971). The Challenger Expedition yielded the massive protistological landmark works of Brady on the Foraminifera (Brady, 1884) and Haeckel on the Radiolaria (Haeckel, 1887).

There are good reasons for placing Carpenter among the early and close allies of Charles Darwin. Carpenter was actually a long-time associate of Charles Darwin; they began corresponding in 1844. In 1847, Darwin visited Carpenter's house and following his advice, Darwin bought two Smith & Beck microscopes for his studies on barnacles. In 1858, Carpenter was in the audience of the reading of the first public presentation of his Darwin's theory, the joint Darwin-Wallace paper on Natural Selection that was read at the Linnean Society. Darwin sent Carpenter an advance copy of the *Origin of the Species* in November of 1859 hoping he would publish a review of it and Carpenter did, in the *National Review* in January of 1860 (Carpenter, 1860b). In his review, Carpenter remarked on Darwin's admission that the fossil record is 'extremely imperfect' with regard to providing evidence of changes in lineages of organisms. One particular 'imperfection' of the fossil record, the lack of any record of life pre-dating the Cambrian period, rich with trilobites, came to be known as "Darwin's Dilemma" (Schopf, 2000): how did Cambrian life suddenly appear in the form of multi-cellular organisms? Periods earlier than the Cambrian appeared to be "azoic". When Logan arrived with his Eozoon material and reports, the dilemma appeared to no longer exist, here was a record of pre-Cambrian life in the form of a fossil protist, a foraminifera.

When Logan finally saw Carpenter after the Bath meeting in 1865, his visit is said to have rejuvenated Carpenter who had been ill since 1864. According to his son's memoir (Carpenter and Carpenter, 1899), Carpenter's condition was dire and his transformation was quite remarkable:

The long strain which he had put upon his energies seemed to have exhausted his natural powers of recovery. The eminent medical men who met in consultation at his house, and detected the presence of permanent disease, said to themselves beneath their breath outside the door of the patient's room, "He has one foot in the grave already." Music ceased to charm; his scientific investigations were laid aside; his Foraminifera and his Comatulæ remained undisturbed. It seemed as though he had become prematurely old; torpor crept over him and numbed his activities; the weeks passed by listlessly and mounted into months, and he gained no strength. The fears of his friends appeared on their way to verification, when one day Sir William Logan, the head of the Geological Survey of Canada, called upon him, bringing with him some specimens from the great beds of the Canadian limestones,

on which he asked his opinion. Dr. Carpenter's quick eye at once detected in them a remarkable affinity to the foraminiferal structure with which he was so familiar. His interest was again powerfully awakened; the "will to live" revived; he began to make microscopic preparations, and entered with much of his former zest on a new path of inquiry, with the result that here gained some of his old vigour, and became the ardent champion of the truly organic character of the rock in question. Here, as he believed, was the earliest known form of animal existence; it was the *Eozoon*, "the dawn of life."

Carpenter must have begun work earnestly and quickly on the materials brought to him by Logan. As mentioned above, Logan's visit to Carpenter was in October of 1864 and it was in November that Logan read his paper on *Eozoon* to the Geological Society of London along with the papers of Dawson, Hunt and one by Carpenter entitled "Additional note on the structure and affinities of *Eozoon canadense*". Carpenter's paper on *Eozoon* was published in March of 1865, along with those of Logan, Dawson and Hunt. It would be the first of 37 publications on *Eozoon* authored or co-authored by Carpenter (Hofmann, 1971). In his first paper, Carpenter made his case for considering *Eozoon* to be the fossil remains of a foraminifera. The plates accompanying Carpenter's text (Fig. 4), like those of Dawson (Fig. 3), showed features not immediately recognizable as structures of a life form, much less as reminiscent of those of foraminifera. However, Carpenter soon after, in April of 1865, published an article in the semi-popular periodical *The Intellectual Observer* with a striking color illustration of his conception of the appearance of a living *Eozoon* (Fig. 5). The illustration would later appear in all the subsequent editions of his book "*The Microscope and Its Revelations*".

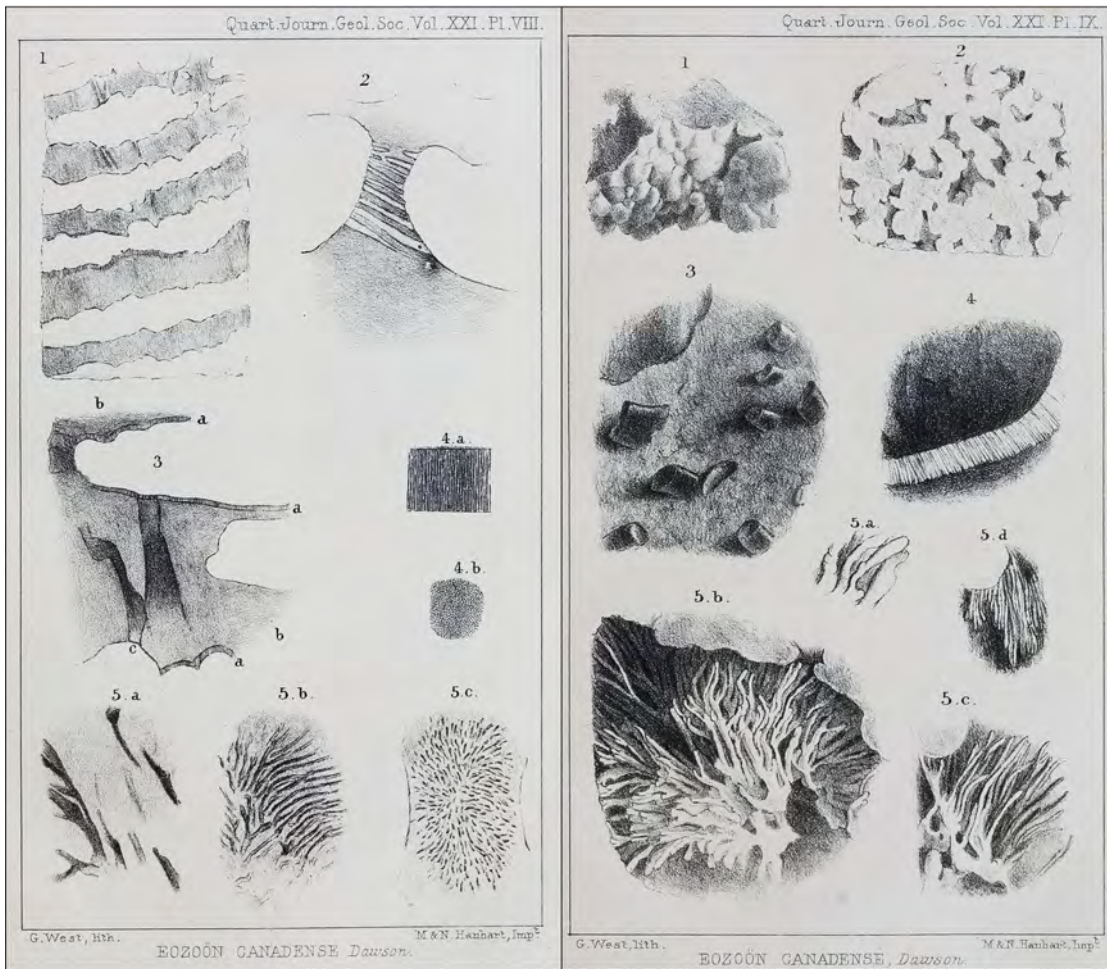


Fig. 4. The illustrations from Carpenter's "Additional note on the structure and affinities of *Eozoon canadense*" (Carpenter, 1865a) published with Dawson's species description (Dawson, 1865a). The figures depict the microscopic structures seen in Carpenter's various preparations of the specimens given to him by Logan. The complete original figure legends are given in the supplementary file.



Fig. 5. A supposed reconstruction of *Eozoon* from an 1865 article by William Carpenter in the *Intellectual Observer*. The complete original figure legends are given in the supplementary file.

Public contestation concerning the nature of *Eozoon*, followed by a rapid and sharp rebuttal by Carpenter, began in June 1865. A short notice was published in the London weekly "*The Reader*" on June 10th by William King and Thomas Rowney, Professors of mineralogy and chemistry, respectively, at the relatively new and small, Queen's College of Galloway in Ireland. The notice stated that they had examined specimens from Connemara similar to those of Canada and had, regretfully, come to the conclusion that the "... *the skeleton-structure of a foraminifera are nothing more than the effect of crystallization and segregation*" and proposed to soon lay before the public all the evidence (King and Rowney, 1865a).

Carpenter did not wait to see the promised evidence of King and Rowney. His response appeared the following week in *The Reader* (Carpenter, 1865d) and was simply an unabashed attack on the personality and competence of King and Rowney. Carpenter wrote "... *Professor King hasards denials of statements by men who have a scientific reputation to lose, in regard to matters which they carefully investigated*". Carpenter's vitriol likely referred to an 1864 article by King in which he contested the view of Thomas Huxley, that Neanderthal man was the same species as *Homo sapiens* (King, 1864). Huxley was a close friend of

Carpenter and both were editors of the *Natural History Review* (Barton, 2018) in which appeared Huxley's article's against King's view of Neanderthal (Huxley, 1864). Today King's description of *Homo neanderthalensis* is recognized as a landmark contribution (Walker et al., 2021) but at the time it was contested. With regard to Rowney, Carpenter dismissed King's co-author stating "... it is scarcely to be supposed that a Professor of Chemistry should claim authority on *Microscopic Paleontology*".

King's reply noted the undignified and intemperate style of Carpenter and regretted that he had not waited to see their evidence (King, 1865a). King attributed Carpenter's aggressivity to a disagreement they had over the morphology of a brachiopod shell some ten years earlier in the pages of the *Annals and Magazine of Natural History*. The exchanges, in print at least, were courteous in 1857 (e.g., King, 1857). The same issue of *The Reader* carried a letter from John Macvicar stating that the structures in the *Eozoon* minerals could be complex crystals of serpentine showing an "exquisite and quasi-organic structure" (Macvicar, 1865). Carpenter's following letter published in July (Carpenter, 1865e) mainly concerned reiterating his view of the brachiopod shell as well as *Eozoon* and was in kind answered in August by King (King, 1865b). Thus, the first war of letters in *The Reader* involved both new and old disputes between Carpenter, the Registrar of the University College in London and King, a Professor in a provincial college.

In 1866, in the January issue of the *Quarterly Journal of the Geological Society*, King and Rowney's article appeared entitled "On the so-called 'Eozoonal Rock'" (King and Rowney, 1866). Carpenter had obviously been given an advance copy of King and Rowney's article as his "Supplemental notes on the structure and affinities of *Eozoon canadense*" (Carpenter, 1866) was printed directly following their article. In his article, Carpenter rebutted King and Rowney's assertions, not directly, but in a series of very lengthy footnotes and accused them of having no knowledge of fossilization processes nor of foraminifera, either living or fossil. Carpenter more formally rebutted King and Rowney's view as to mineral nature of *Eozoon* in a review published in the *Philosophical Transactions of the Royal Society* (Carpenter, 1867).

By 1868, Carpenter was occupied by deep dredging expeditions, the voyages of the *Lightening* and the *Porcupine* (e.g. Carpenter and Wyville Thomson, 1869). The expedition results were used by Carpenter to justify the need and utility of a world wide exploration of the deep sea that would be the Challenger Expedition of 1873 to 1876. By this time, *Eozoon* had received widespread acceptance, for example cited by both Ernst Haeckel and Thomas Huxley as extending the fossil record of life (Haeckel, 1866; Huxley, 1868a) and among the most remarkable discoveries in geology of the decade by Joseph Dalton Hooker (Hooker 1869).

Eozoon even made its appearance in the 1869 fifth edition of Darwin's "*Origin of the Species*" (Darwin, 1869).

Carpenter returned to a defense of *Eozoon* in the second 'duel' of letters in 1870-1871, this time in *Nature*. It began in December of 1870 when Thomas Reade, a civil engineer, amateur geologist, and architect of Liverpool (Anon., 1909b), wrote a letter to *Nature* published on December 22. Reade stated, that in his opinion, *Eozoon* had heretofore been examined only with the *a priori* that it was a fossil and had only been found in metamorphic rock deposits, not in any unaltered rocks. He concluded that *Eozoon* would become extinct when impartial geologists took up the question of its organic or inorganic nature (Reade, 1870). As one might imagine, Carpenter was quick to reply and his retort appeared on January 5 of 1871 (Carpenter, 1871a). Oddly enough, Carpenter cited only the opinions a number of eminent zoologists and no geologists in defense of *Eozoon*. Recall that one of the first advocates of *Eozoon* was Charles Lyell. On February 2, three letters appeared. Dawson wrote of his intention to address Reade next week (Dawson, 1871a). A newcomer appeared, G.H. Kinahan, a distinguished Irish geologist (Anon., 1909b), writing that *Eozoon* was found only in 'peculiar rocks' in Ireland (Kinahan, 1871). Reade's letter on February 2 simply stated the fact that Carpenter had not explained why *Eozoon* had been found only in metamorphic rocks and not unaltered limestone (Reade, 1871a). Next Dawson joined the fray in earnest in a letter published on February 9 (Dawson, 1871b). Reade replied in a letter appearing on March 9, stating the in the exchanges no new evidence had been brought forward in support of the organic nature of *Eozoon*, nor had any explanation of why *Eozoon* was found only in metamorphic deposits been provided (Reade, 1871b). Carpenter's last letter, published the following week (Carpenter, 1871b), ended with a paragraph, not countering Reade's arguments, but rather attacking his right to raise questions. This would be a typical tactic of Carpenter in his years of defending *Eozoon*.

"Since I do not feel called upon to expend valuable time in giving to Mr. T. Mellard Reade the instruction which he requires to qualify him for discussing this question, I now leave him to the enjoyment of his own opinion. Whenever he shall have shown, by work of his own, his competence to criticise the observations of other who have made a special study of the subject discussed, I shall be happy to afford him the same opportunity of forming his judgment as to the organic nature of Eozoon, by an examination of my preparations, that I have given to the many eminent naturalists, who have fully satisfied themselves of the justice of my conclusions."

William King the first critic of Eozoon

In common with most other critics of *Eozoon*, information on the life and career of William King is rather sparse in comparison to the well known *Eozoonists*. The following biographical account of King is based on Pettigrew (1979), Turner (1979), and Murray et al. (2015, 2020). I could find no information on King's

usual co-author on *Eozoon*, Thomas H. Rowney, hence, he here remains neglected.

William King is said to have been born in 1808 (apparently no records exist) in Sunderland, in Northern England. His father was a 'coal caster' and his mother held a confectioner's shop. After primary school he was apprenticed to a firm of ironmongers. In 1833, at the age of 25 he opened a bookstore and stationary shop that became a meeting place of the literary and scientific personalities of the city. King was soon named secretary and librarian of the Sunderland Literary and Philosophical Society. In 1836 he was the first curator of the newly formed Sunderland Natural History and Antiquarian Society. In 1840 King was named Curator of the Hancock Museum in Newcastle. He lost his job in 1847 as he refused to forgo his sideline activity of selling geological specimens to supplement his meager income.

In 1848 King applied for a professorship in Geology in one of the 3 new Queen's Colleges to be established in Ireland in Cork, Galway and Belfast. The colleges were intended to provide non-denominational higher education in Ireland and correct the imbalance of the dominance of Trinity College Dublin, associated with Anglican Church. Through his lectures and publications on fossils and geology, King had become relatively well known. However, he held no diplomas. His application for a professorship was supported by important personalities, ironically enough, including Charles Lyell, Dawson's mentor. The beginning of the Queen's Colleges coincided with the very difficult times in Ireland of the Great Famine. Galway, where he was named Professor of Geology and Mineralogy, was geographically isolated and in dire economic condition. Nonetheless, King published abundantly on a wide range of topics. As mentioned above, King's work on brachiopod fossils was known to Carpenter and it is likely that King's reports on the nature of the deep sea bed based on material from soundings of the *Porcupine* (King, 1862a,b) and his negative opinion on Darwin's *Origin of the Species* (King, 1862c) were known to Carpenter.

King and Rowney's first detailed critique of *Eozoon* (King and Rowney, 1866), began by stating that their studies at first aimed simply to date the Connemara marble deposits, near Galway, that had been reported to contain *Eozoon* structures by J. Rupert Jones (1865), a co-worker of Carpenter. However, their examinations of material from the original Canadian site (sent on their request by Logan), and other sites in the United States and Europe, convinced them that the structures in eozoonal deposits were likely mineral and did not conform to structures known in foraminifera. In their report, they presented a gallery of images of mineral structures (Fig. 6) resembling organic structures. As mentioned above, Carpenter's article attacking their conclusions was printed in the pages directly following King & Rowney's article (Carpenter, 1866) and did

not offer any new evidence nor was any provided in Carpenter's subsequent review (Carpenter, 1867).

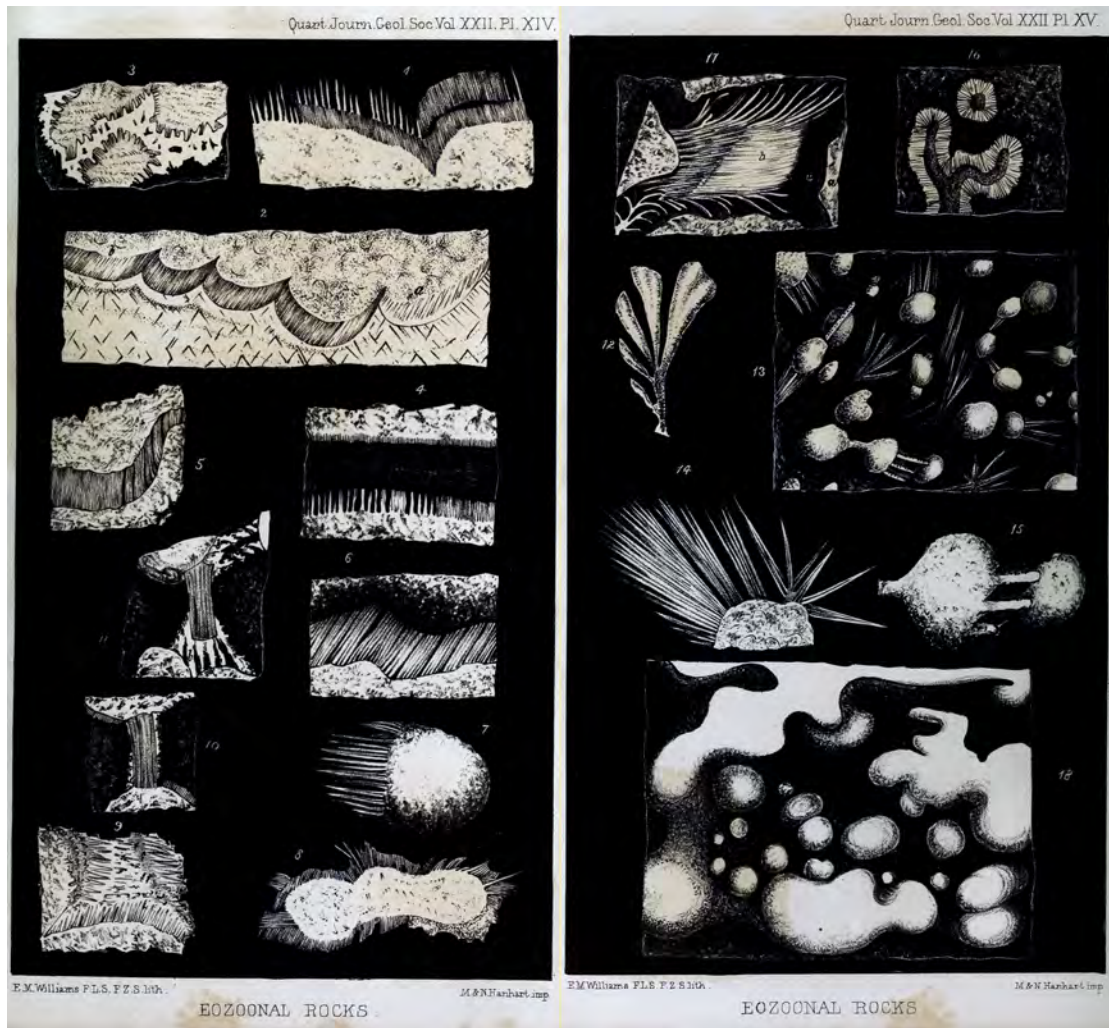


Fig. 6. The two plates from King & Rowney (1866a) "On the supposed Eozoon". Microscopic mineral structures are shown that could be confused with organic remains. The complete original figure legends are given in the supplementary file.

One of the most substantial works published on *Eozoon* was quite likely their second article "On *Eozoon Canadense*" consisting of 48 pages of text and 3 plates (King & Rowney 1869). It was answered by Dawson (1871c) in the now time-honored manner of asserting the ignorance of King and Rowney, and the authority of others supporting the view that *Eozoon* was a fossil. The response of King and Rowney (1871) to the attacks by Dawson also conformed to previous encounters as the lack of any new evidence from Dawson was pointedly emphasized. In subsequent years, King and Rowney continued to put forth their view of the mineral nature of *Eozoon*. Their final effort was a book published in 1881, just two years before a paralytic attack incapacitated King and 5 years before his death. Its long title left no doubt as to the aim of the work: "*An Old Chapter of the Geological Record with a New Interpretation: or, Rock-*

Metamorphism (especially the methylated kind) and its Resultant Imitations of Organisms with an Introduction giving an Annotated History of the Controversy on the So-Called 'Eozoon Canadense' and an Appendix". Interestingly, King's obituary notice in *Nature* (Anon., 1886) made no mention of *Eozoon* nor of *Neanderthal*.

Despite their efforts, King and Rowney were joined by only a few others in the early years in denying the organic nature of *Eozoon* publically (i.e., Burbank, 1871; Perry, 1871). However, occasionally mention of the passing of *Eozoon* appeared. For example, the notice "A Fallen Fossil" in the *British Medical Journal* (Anon., 1872). The next critic was seemingly unlikely to have troubled *Eozoon*. It was Henry Carter, a retired medical doctor and frequent writer on foraminifera, known to Carpenter.

Henry Carter the first defender of King

Henry Carter was an improbable opponent for Carpenter in the third and last of the lengthy public duels over the nature of *Eozoon*. Carter was a contemporary foraminifera authority. About Carter's life, the only available information appears to be an obituary notice (WTB, 1895). Carter was born in 1813. He studied medicine at University College (where Carpenter would become Registrar) and in 1841, engaged by the East India Company, left for India. He served in a variety of positions over the next 20 years. In 1862 he retired, and returned to England.

Carter published extensively on a variety of protists for example, rhizopods (Carter, 1865a), diatoms (Carter, 1865b) and ciliates (Carter, 1865c). However, most of his publications were on foraminifera, both living and fossil, and he was likely considered an authority. In Carpenter's "*Introduction to the study of Foraminifera*" (Carpenter, 1862), the list of bibliographic references included 8 papers by Carter compared to 5 by Carpenter himself. The obituary notice on Carter (WTB, 1895) stated that he had published 28 papers on foraminifera. Carpenter's previous battles had been with geologists. This last *Eozoon* 'duel' Carpenter waged began against a person well acquainted with foraminifera, especially the fine structure of the larger forms both fossil and living (e.g. Carter, 1853a,b), and it eventually even drew King back into the fray.

The duel took place in the *Annals and Magazine of Natural History* (from hereon *Annals*) in 1874, and began with the March issue in which appeared "On the structure called *Eozoon canadense* in the Laurentian limestone of Canada" (Carter, 1874). Oddly, it was a letter by Carter originally addressed to King in Galway, published without any notice of who sent it to the *Annals*. In the letter, Carter thanked King for copies of his papers and for "*the decalcified slice of Laurentian limestone (about 2 x 2x 2/8 inch in size), which you state to be from Canada and to have been forwarded to your colleague Professor Rowney by Dr.*

Carpenter as a 'typical specimen of Eozoon canadense'." Carter concluded that the specimen he received from King, originally from Carpenter, "*presents no foraminiferal structure*". Carpenter's reply in the following issue of the *Annals* (Carpenter, 1874a) took the greatest exception to the fact that Carter had not cited any of the 'pro-Eozoon' articles. Carpenter presented again the illustrations he had had drafted to show his conception of the living *Eozoon* (e.g., Fig. 5), from the 1865 article in the *Intellectual Observer*, and asserted that many eminent scientific men had examined his specimens and accepted his interpretations.

Carter's response appeared in the May issue of the *Annals* and he argued that the minute structure of *Eozoon* was fundamentally unlike that of known forms of foraminifera (Carter, 1874b). His arguments received wide coverage, for example, summarized in an article in the *American Journal of Science and Arts* as "*Eozoon canadense not a foraminifer or calcareous rhizopod secretion*" (Carter, 1874c). In the same issue of the *Annals* with Carter's response to Carpenter, was an article by King and Rowney reiterating arguments that all of the structures known in *Eozoon* could be mineral formations and that *Eozoon* was still only known from metamorphic rocks (King and Rowney, 1874). The June issue of the *Annals* carried Carpenter's responses to Carter and King (Carpenter 1874b) including a statement of his willingness to let them examine his specimens. Strangely enough, without any response from Carter or King, the December issue of the *Annals* carried "Final note on *Eozoon canadense*" by Carpenter (Carpenter, 1874c). It did not address Carter, but only King and Rowney! It ended with the conclusion "*As I should now no more think of attempting to convince the Galway 'infallibles', than of trying to convert the Pope, I leave them in triumphant possession of the field. Your readers, perhaps, may claim the exercise of 'private judgment' in the matter*".

Carpenter subsequently published little on *Eozoon*; it fell mainly to Dawson to defend *Eozoon* from the first two of the critics presented in the following sections: Mobius and Johnston-Lavis.

Karl Mobius the most regretful critic of Eozoon

Karl Mobius was a German zoologist. Born in 1825, at the age of 43 in 1868 he was a named Professor of Zoology at the new University of Kiel. He worked on a wide variety of marine invertebrates and protists, including rhizopods (e.g., Mobius, 1876). In 1878 he published his study of *Eozoon* material in a monograph consisting of 16 pages of text and 17 plates published in the November issue of the German journal *Paleontographica* (Mobius, 1878). He had solicited material from Carpenter and began his study of *Eozoon* because he had found and described as a new species of foraminifera, *Carpenteria rhapsidodendron*, and thought it may resemble *Eozoon*. Importantly, his study was based on material and slides of Dawson or Carpenter and he concluded that the

structures of *Eozoon* bore no resemblance to those in living foraminifera (e.g., see Fig. 7). It did not take long before Mobius's study was given a good deal of attention in the English language scientific press.

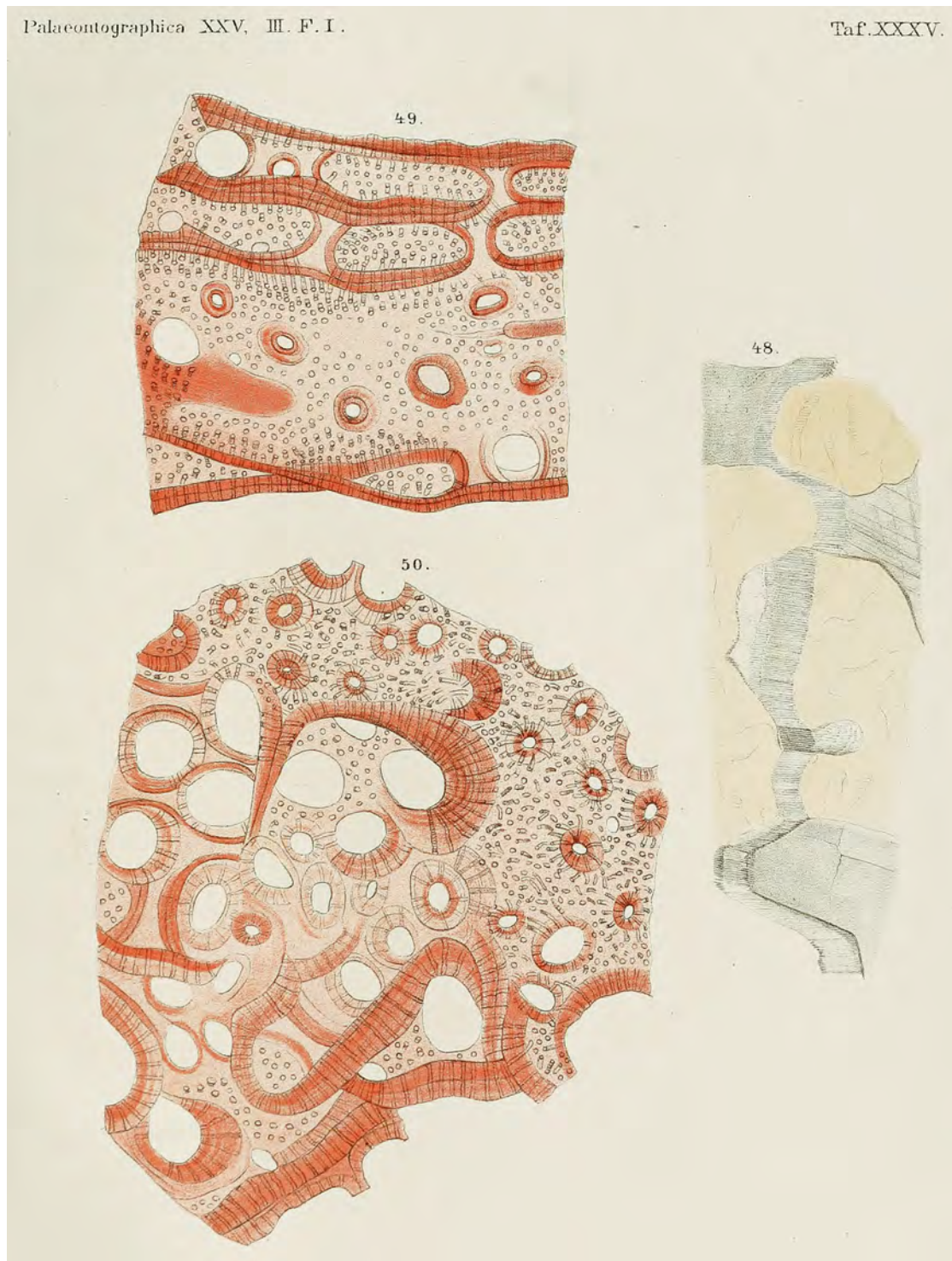


Fig. 7. A plate from the 1879 article by Karl Mobius comparing the apparent anatomy of *Eozoon*, from slides supplied by William Carpenter and William Dawson (fig. 48) with sections of recent benthic foraminifera (figs. 49 & 50) thus showing the lack of correspondence in fine structure between *Eozoon* and contemporary foraminifera. A translation of the complete original figure legends of the plate are given in the supplementary file.

The first notice appeared, not surprisingly, in the *Annals* in April of 1879, signed T.R.J. (likely Carpenter's fellow foraminifera expert, T. Rupert Jones). The conclusion of the notice (T.R.J., 1879), suggests respect for the evidence shown and the conclusion of Mobius:

"This memoir is a handy resumé of the objections made by anti-eozoonists to the presumed organic origin of the object under notice; and the plates brought together by Prof. Mobius, with no little labour and skill, are useful as a compendious set of sectional figures of Eozoon and many of its more modern relations; and though he fails to see their alliance, close as the analogies may be, yet his work is highly useful and praiseworthy; it is disinterested, straight-forward, and conscientiously offered for the advancement of true knowledge."

Subsequently Mobius's study was summarized in *Nature* in the 1879 issues of July 17 and July 24 (Mobius, 1879a). It was presented as a de-bunking of *Eozoon* with many of his illustrations of *Eozoon* in comparison to modern foraminifera. Carpenter emerged from his silence on *Eozoon*, and reacted with a letter published on July 31 in *Nature* asking that judgment be withheld as to the nature of *Eozoon* until the appearance of a monograph he was preparing with Dawson (Carpenter, 1879). The monograph mentioned never appeared but Dawson did not remain silent. Dawson's rebuttal of Mobius was first published in the *Canadian Naturalist* (Dawson, 1879a) and then reprinted in the *American Journal of Science and Arts* (Dawson, 1879b) as well as in *Nature* (Dawson, 1879c), forwarded to *Nature* by none other than Carpenter. However, it was relatively weak and it was not clear if Dawson had actually read Mobius's article himself. Dawson stated that observations of *Eozoon* in situ were needed for a correct assessment, that Mobius had a limited number of specimens some no doubt "from dealers or injudicious amateurs", and that Mobius had considered the Eozoonal structures individually rather than as a whole. Mobius requested an opportunity to reply to Dawson's critique in the *American Journal of Science and Arts* and in his reply (Mobius, 1879b) expressed astonishment at the objections of Dawson. Mobius reiterated his published statement the *Eozoon* specimens were all from Carpenter or Dawson and asked rhetorically how many specimens needed to be examined for a correct assessment. Dawson responded with a surprisingly insulting piece in the *Canadian Naturalist* accusing Mobius of "willful falsification" and "inexcusable ignorance" (Dawson, 1879d). Mobius prudently left Dawson's attack undignified by a response. Undeterred by Dawson's accusation of ignorance, Mobius published in 1880 his sumptuous monograph on the foraminifera of Mauritius (Mobius, 1880), the work that had brought him to *Eozoon*.

Mobius's work put *Eozoon* into serious doubt. For example, in his Presidential Address to the Geologists Association, Hicks in 1882, simply stated "*The Eozoon is still regarded of so doubtful a nature that I do not call special attention to it*"

(Hicks, 1882). Thomson's 1885 book, "*Bibliography of Protozoa, Sponges, Coelentrata, and Worms*", listed papers on *Eozoon* under the category 'Doubtful Forms ascribed to Rhizopoda' (Thompson 1885). Carpenter passed away in 1885 leaving Dawson alone to defend of the organic nature of *Eozoon*.

Henry James Johnston-Lavis put the 'nail in the coffin' of Eozoon

What little we know of Henry James Johnston-Lavis (1856-1914) is from a three page obituary notice published in *Geological Magazine* (Anon., 1914a) and an appreciation of his collections related to volcanism housed in University College (Kirk et al., 2000). He was professionally a medical doctor and secondarily a geologist. Johnston-Lavis became a specialist on volcanoes, those of Southern Italy. In 1879 he moved to Naples where he could combine a medical practice with his studies of volcanoes, especially the minerals formed in eruptions. He stayed in Naples until 1893 when he moved to the South of France and practiced medicine in Nice in the English Queen Victoria Hospital. Johnston-Lavis died in an automobile accident in 1914 at the age of 58.

Johnston-Lavis published on medical matters and extensively on the minerals formed in volcanic eruptions (e.g., Johnston-Lavis, 1885), including studies of the microscopic structures formed in the minerals (e.g. Johnston-Lavis, 1886). He entered the fray concerning the nature of *Eozoon* in 1893 when he "exhibited a series of specimens from Vesuvius, illustrating the structure of *Eozoon*" at the June meeting of the Geological Association (Anon., 1893). This was followed by the publication in the *Transactions of the Royal Dublin Society* in October of 1893 of "Eozoonal structure of the ejected blocks of Monte Somma" (Johnston-Lavis and Gregory, 1894). The article included 4 plates showing microscopic structures greatly resembling those characteristic of Eozoonal deposits (e.g., Fig. 8).

(FIG. 1.) $\times 14\frac{1}{2}$.



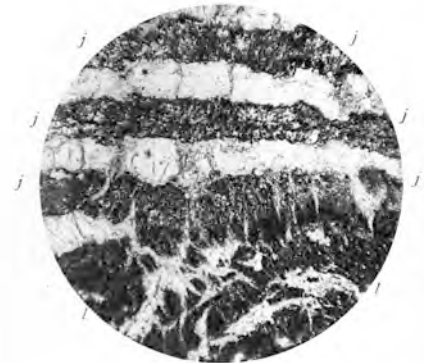
(FIG. 2.) $\times 14\frac{1}{2}$.



(FIG. 3.) $\times 24$.



(FIG. 4.) $\times 24$.



(FIG. 5.) $\times 14\frac{1}{2}$.



(FIG. 6.) $\times 24$.



Johnston-Lavis, photo.

University Press, Oxford.

Fig. 8. Plate 31 from Johnston-Lavis and Gregory (1894) showing Eozoonal structures in sections of volcanic ejecta from Mont Somma. The complete original figure legends are given in the supplementary file.

Showing *Eozoon* structures in rocks ejected during volcanic eruptions, igneous rocks, was said by Gould to have been the 'nail in the coffin' of *Eozoon* (Gould, 1980). Indeed soon appeared "*Eozoon: Requiescat in Pace*" in *Natural Science* (Anon., 1895). Nonetheless, Dawson maintained the organic nature of *Eozoon* claiming that the structures found by Johnston-Lavis and Gregory in volcanic rocks differed in lacking some of the microscopic structures of his *Eozoon* (Dawson, 1895). Johnston-Lavis, perhaps wisely, as an expatriate medical doctor without any diplomas in Geology, did not reply to Dawson's critique. In his later work, Johnston-Lavis continued to describe new minerals formed through volcanic activity (e.g., Johnston-Lavis, 1906). The obituary notice in *Nature* for Johnston-Lavis mentioned the 1894 article on *Eozoon* as one of his most important memoirs "*in which the non-organic origin of the one-time famous Eozoon canadense was finally demonstrated*" (Anon., 1914b).

Despite the obituary notice, and modern declarations that the study of Johnston-Lavis and Gregory settled definitively the matter of *Eozoon* (e.g. O'Brien, 1970; Gould, 1980; Brasier, 2009; Schopf, 2009), at the end of the 19th century, *Eozoon* was still not fully settled. *Eozoon* was not described as abandoned, but rather "*much-disputed*" (Poulton, 1896) or "*highly problematic*" (Morris, 1896). In 1899 Dawson, the indefatigable defender of *Eozoon*, passed away and that same year was published an "*Intermediate Text-Book of Geology*" which described *Eozoon canadense* as "*discredited by most geologists*" but the book nonetheless included illustrations of it (Lapworth, 1899). Years later, *Eozoon* would be revived briefly in what Heron-Allen would liken to a case of Palingenesis (Heron-Allen, 1915), by the last advocate of the organic nature of *Eozoon*, but in a startlingly new form, by Randolph Kirkpatrick.

Randolph Kirkpatrick the Reviver of *Eozoon*

Nearly all that is known of the life and unusual views of Randolph Kirkpatrick are from just a few sources: a short obituary notice published the year of his death in 1950 (Burton, 1950), an essay by Gould "Crazy Old Randolph Kirkpatrick" (Gould, 1980) and two pages in Fortey's book "Dry Storeroom No. 1: The Secret Life of the Natural History Museum" (Fortey, 2009).

Kirkpatrick was born in 1863 just a year before Logan first announced the discovery *Eozoon*. He was named Assistant Keeper of Zoology of the British Museum (subsequently The Natural History Museum) in 1886, and retired in 1927 as Keeper of Zoology. His specialty was the 'lower invertebrates', the protozoa, porifera, and hydrozoa, and he was the main author of the "*Guide to the Coral Gallery*" of the Museum, which included a good deal on protists (Anon., 1907). He published abundantly on sponges but also occasionally on radiolaria (Kirkpatrick, 1889) and medusa (Kirkpatrick, 1903). Among sponge specialists, he is today credited with being among the first to recognize that the reef-

building, enigmatic, stromatoporides were encrusting sponges, but in his time he lost all credibility when he claimed that the stromatoporids were actually composed of large foraminifera and that *Eozoon* was composed of small foraminifera (Wood, 1990). Kirkpatrick was then an opponent of Dawson and Carpenter's view because he claimed *Eozoon* was not a large foraminifera but rather a colony of small forms, and a proponent of *Eozoon*, as the remains of organisms.

Following the now well-worn path of previous workers on *Eozoon*, Kirkpatrick first announced his discovery in *Nature* (Kirkpatrick, 1912a,) and published the details of his claim in a pair of article in the *Annals* (Kirkpatrick, 1912b,c). He subsequently claimed that all minerals were composed of some form of foraminifera fossils and that foraminiferal structure could be found even in meteorites. None of these latter extreme assertions appeared in the scientific press, but were made in four self-published pamphlets on "*The Nummulosphere*". Figure 9 is taken from Kirkpatrick's 1916 "*Nummulosphere Part III. The Ocean Floor or Benthoplankton*". According to Burton's obituary notice on Kirkpatrick, toward the end of life he privately admitted that he 'had been misled' (Burton, 1950). Kirkpatrick should be recognized for having, however oddly and briefly, brought *Eozoon* back into the public eye.

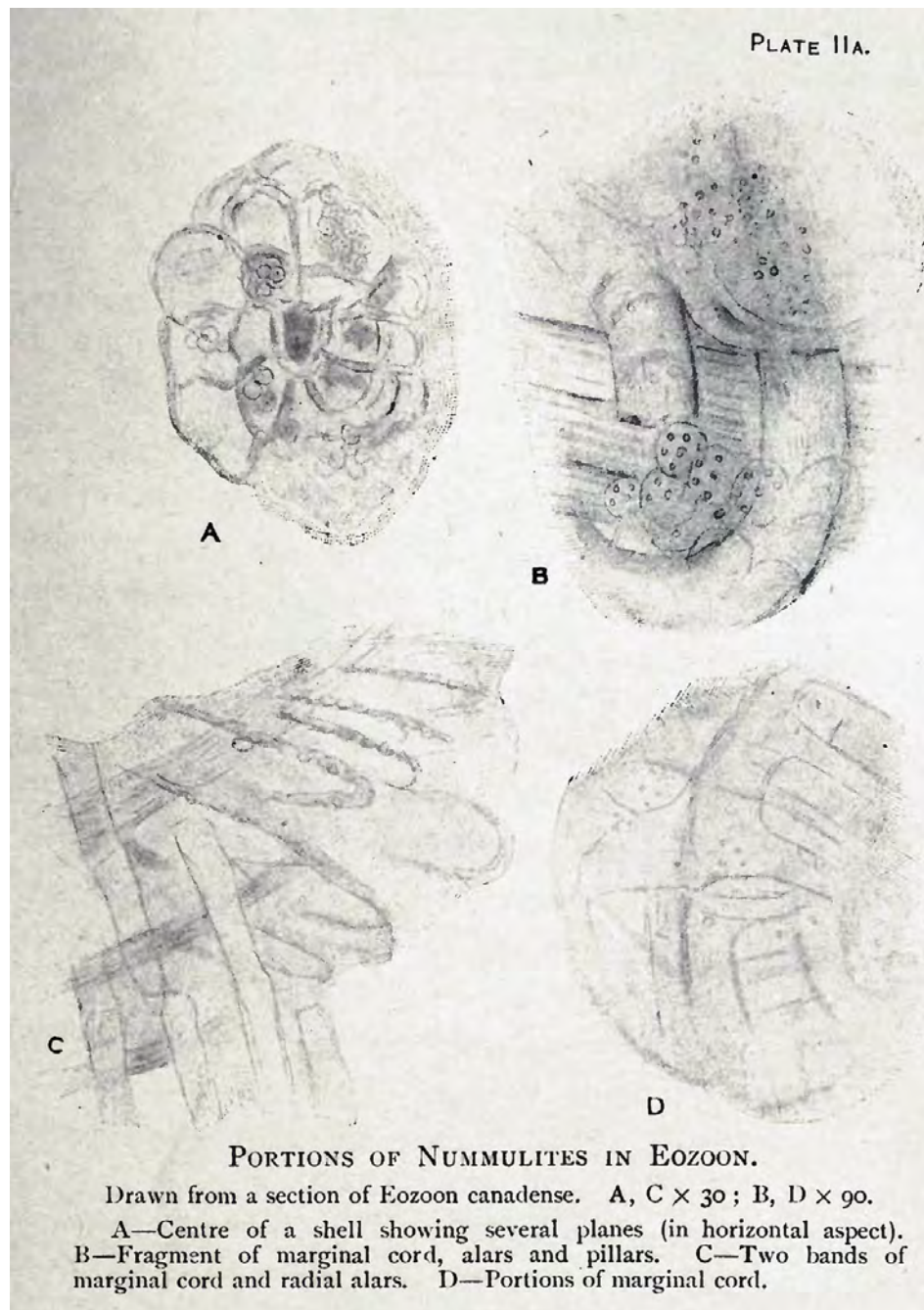


Fig. 9. A plate from Kirkpatrick's 1917 book "*The Nummulosphere*" illustrating his claim that *Eozoon* was composed of pieces of nummulite foraminifera, the true primordial animal.

Epilogue

To paraphrase a quote attributed to Mark Twain, the rumor of the death of *Eozoon*, announced with some authority at least three times, was each time, an exaggeration. King and Rowney believed that they had disproved the organic nature of *Eozoon* in 1866. Some 13 years later, Mobius clearly felt he had to show that *Eozoon* was not a fossil forminifera, as did Johnston-Lavis when he announced his discovery of *Eozoon* structures in volcanic ejecta in 1894. However, throughout these years, and well into the 20th century, *Eozoon* did not completely disappear. A simple literature search for works containing the term "*Eozoon canadense*" brings up examples of the pseudofossil presented as the primordial life form in a 1922 article in *Scientific American* entitled "The Earliest Inhabitant" (Butterfield, 1922), and (sadly!) a 1947 High School biology text, "*Modern Biology*" (Moon et al., 1947). In both these instances, the illustrations used appeared to have been copied (without attribution) from Carpenter's well-known manual of microscopy "*The Microscope and its Revelations*" (see Fig. 10). The last two editions, published after Carpenter's death, retained intact the Carpenter texts and illustrations from earlier editions presenting *Eozoon* as the primordial life. Thus Carpenter's outdated, but apparently authoritative views and illustrations, were still in wide circulation. The appearance of *Eozoon* as the primordial life form in works published decades after Carpenter's death and demise of *Eozoon* can be taken as a tribute to the authority of Carpenter, or perhaps more wisely, as examples of the need to verify even apparently authoritative accounts.

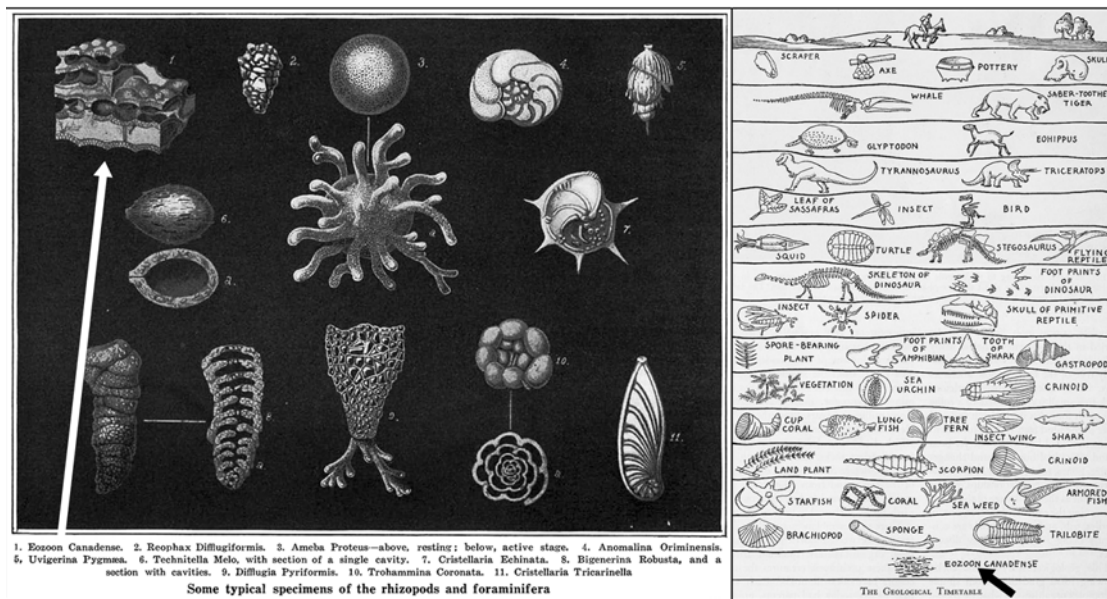


Fig. 10. Examples of the presentations of *Eozoon* as a primitive rhizopod fossil (arrows added) that appeared well into the 20th century. Left panel is a figure from Butterworth's 1922 article in *Scientific American* (Butterworth, 1922). The illustration is a copy of Figure 641 (pg. 839) in the last edition of Carpenter's book, *The Microscope and its Revelations* (Carpenter, 1901). The right panel is an illustration from the 1947 textbook *Modern Biology* (Moon et al., 1947). The illustration of *Eozoon* as series of stripes appears as Fig. 640 (pg. 837) of the 1901 edition of Carpenters's book.

The endurance of *Eozoon*, despite credible evidence of it being an artifact, contrasts with the short life of *Bathybius haeckelii*, the other "great mistake of biology" presented by Gould (1980). It was a contemporary of *Eozoon*. Huxley described it as a primordial organism found in preserved samples of mud from the deep sea and named it for Haeckel in 1868 (Huxley, 1868b). Carpenter believed it to possibly be a living form related to *Eozoon*, carpeting the bottom of the deep sea (Carpenter and Wyville Thomson, 1869). When the chemist aboard the *Challenger* discovered it in alcohol-preserved samples of deep sea mud but not in fresh samples, *Bathybius* was publicly renounced by Huxley as an artifact (Huxley, 1875) and no more of it was heard of it except as a curious case study by historians of biology (i.e., McGraw, 1974; Rehbock, 1975; Rice, 1980).

As *Eozoon* was never renounced by its authoritative advocates, it resembles in some respects a more recent 'mistake of protistology', that of the 'neuromortorium', a proto-nervous system, first described by Charles Kofoid and his students in 1914, and long promoted by Kofoid (reviewed in Dolan, 2021). The supposed neuromortorium was a system of fibers in protist cells to which were attributed sensory and motor functions. The existence of the neuromortorium was disputed early on and fibers were shown in some species to be either simply structural, and in others to be fixation artifacts. Nonetheless,

papers continued to appear describing neuromotorium structures in protists well after Kofoid retired in 1936 and only ceased appearing after Kofoid's death in 1947. The end of the neuromotorium, corresponding with Kofoid's death, suggests that it was Kofoid, as a living authority, that kept the neuromortium in existence, much like Dawson and his *Eozoon*. The 'take-home lesson' here is that Knights, Fellows of the Royal Society, Members of the National Academy of Science, President or Chair of this or that, etc., can be just as wrong as you or I. Retaining a critical attitude is still advisable today.

Acknowledgements

Alan Warren kindly provided essential aid in obtaining the image of Randolph Kirkpatrick. The friendly and efficient librarians of the Universitätsbibliothek of the University of Leipzig supplied a copy of the truly exceedingly rare article by Johnston-Lavis and Gregory (1894). The comments and suggestions of David Montagnes and the anonymous reviewers on previous versions of the manuscript are gratefully acknowledged. However, I retain full full responsibility for all errors of fact, omission and interpretation.

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