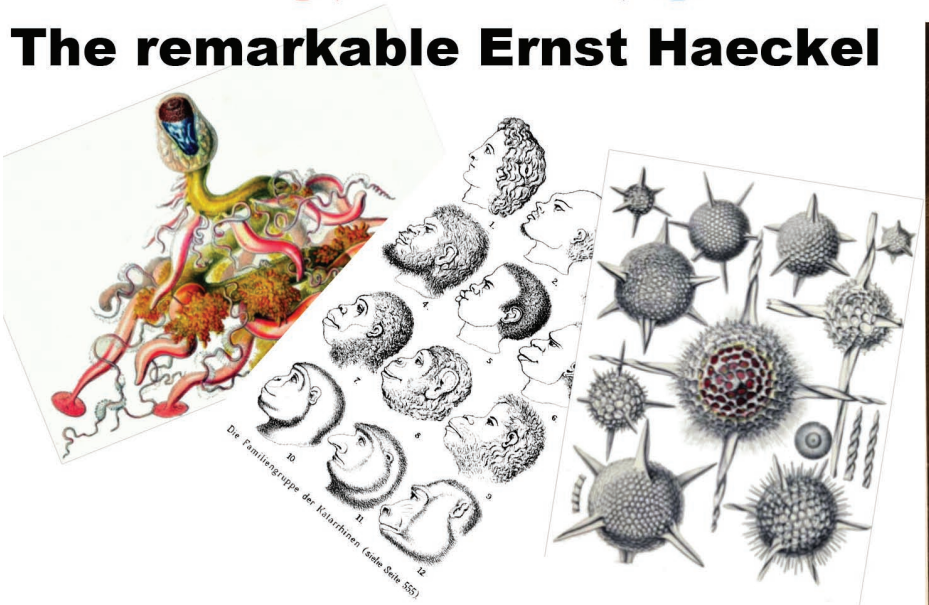
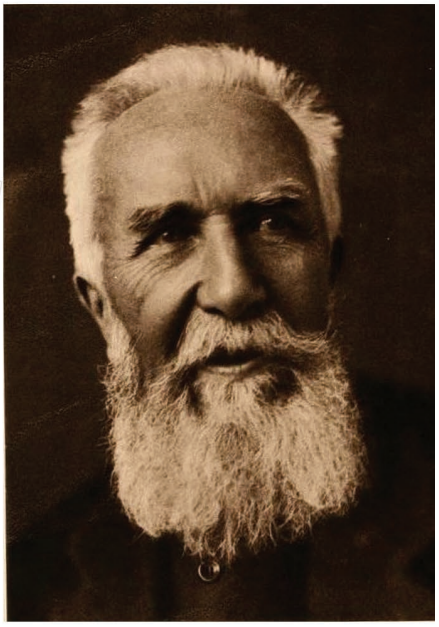
Visionary, heretic, genius or charlatan?

The remarkable Ernst Haeckel





Dylan Evans, Edith Gruber and Peter Williams

Polymath, fraudster, philosopher, eugenicist, revolutionary, proto-Nazi, anti-Semite, genius, visionary … this is only a short list of the many epithets attributed to Ernst Haeckel. He was, without doubt, a driven man whose impact on contemporary and modern scientific thinking, as well on the way that we now see the world, is at least as significant as that of many great scholars through time including, one may argue, his close friend and collaborator Charles Darwin.

Haeckel was an eminent scientist, a converted and militant Darwinist, and an incredibly active and articulate advocate of the public understanding of science. Haeckel's promotion of Darwin's theory of evolution was conducted with a fierceness that eclipsed even that of his British counterpart Thomas Huxley – 'Darwin's bulldog'. Haeckel is regarded as having a greater impact on evolutionary thought at the time in Europe than Darwin did through his own writings.

Haeckel made major contributions to a number of areas in biology, the arts, and also contemporary philosophy. Many terms that are now in common use, for example Caucasian, ecology, metazoan, phylum and stem cell, were coined by Haeckel. Crucially important concepts, such as the separate functions of the cytoplasm and the nucleus in the cell, the proposal that embryos passed through the evolutionary stages of the species ('ontogeny recapitulates phylogeny') also came from him. He brought forward the concept of the protists and gave the group comparable stature to the Plant and Animal Kingdoms. In many respects, although Haeckel's words and concepts are in current use, he is probably better remembered for his art than his science, even amongst scientists. In science, Haeckel is unfortunately remembered by some, and we suggest unjustly, for the little he got wrong, rather than the significant amount he got right, a privilege we normally reserve for politicians. Whatever you choose to make of Ernst Haeckel, it is difficult, in our opinion, to quarrel with our description of him as 'remarkable'. His output, delivery, and the concepts he communicated so well, led him into a host of controversies in several independent disciplines. He was without doubt provocative, and not in the least inclined to hesitate; to this day his work and writing attracts fevered debate.

Here we examine his career, his thoughts, and their impact. We present his art, and his belief in moving boundaries and ideas beyond what is supported by direct evidence. We discuss the way in which he helped to mould the scientific and philosophical landscapes of his time through his contributions to research and to the development of ideas that are still considered fundamental.

Haeckel was a man of his time and he lived through a period of arguably unparalleled advances in the fundamental aspects of biology. Jena, where he held his professorship, was at that time the epicentre of philosophical debate in Germany. We, like others who have studied Haeckel's scientific and other achievements, are of the view that they have to be considered in the context of the scientific and philosophical developments and debates of his times. Accordingly we start by discussing these, before picking up his life history.

The mid 1800s was a period of rapid advances in the understanding of the underlying principles in biology and ecology. Arguably these advances in fundamental concepts in biology in this era were probably significantly greater than those of the past half-century or so. There was of course far greater scope at that time. The modernisation of German universities in the early 1800s gave rise to a breed of professional research scientists who were responsible for major changes in our understanding of the natural sciences. A notable exception to the then German dominance in biology was the development of the theory of evolution by natural selection of Darwin and Wallace. They were the archetypal 'amateur' Victorian British scientists; amateur, however, only in that they were not embedded in an academic institution or paid a salary for their work. Further, and relevant to the ensuing discussion, the links between science and philosophy appear to have been much closer in Germany than in English-speaking countries, and so as a consequence, was the discourse and communication between the two fields of study. Germany's great poet Johann Wolfgang von Goethe, for example, straddled the philosophical and scientific camps. He discovered

Johann Wolfgang von Goethe, aged 30
(Etching by W. Unger after G.O. May, 1779)

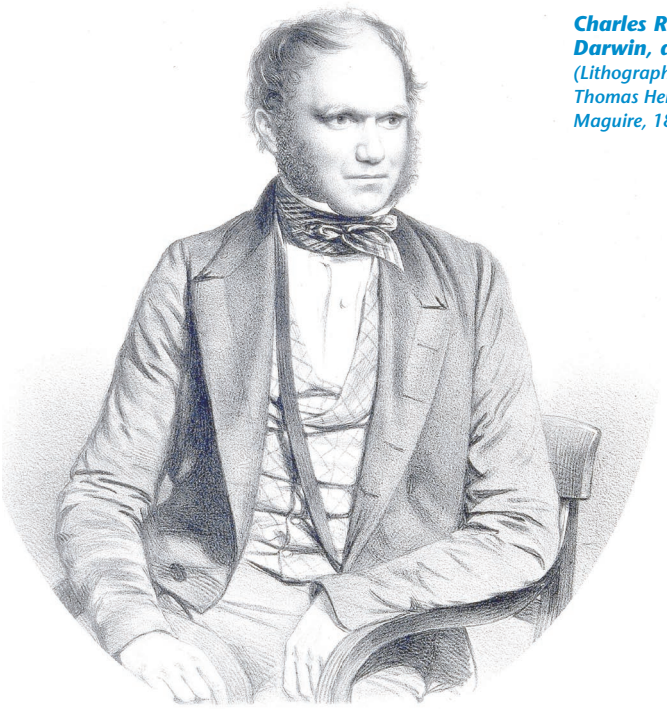
the intermaxillary bone, known also as the Goethe bone in the human embryo; its absence in adults was then thought to distinguish man from the apes. He also put forward the idea that the skull was constructed from modified vertebrae.

A major German scientific advance of the time was the development of cell theory in 1838 by Matthias Schleiden and Theodor Schwann. They put forward the idea that the basic building block of organisms and tissues, both in animals and plants, was the cell – now something we would not give a second thought to, but at the time a quite radical notion. The idea brought with it the question of whether a multicellular organism was truly an individual, or rather a collection of individuals – a conundrum particularly acute in the case of colonial animals such as the siphonophores (e.g. Portuguese Man O'War), a group of marine animals that fascinated Haeckel.

Haeckel's 'props' in a Jena theatre that he rented for a public lecture on 'The problem of Humanity and Linné's Master Animals' in 1907

More or less concurrent was the development of the concept of protoplasm. The term was first used in 1846 by Hugo von Mohl, who described a 'tough, slimy, granular, semi-fluid' in living cells. Huxley felt that it was no less than the 'physical basis of life'. In essence, and accepted now, it is the living contents of a cell, itself surrounded by a plasma membrane. Both ideas are absolutely fundamental to our understanding of life.

Haeckel spent the major part of his scientific career in Jena where he was embedded in a lively intellectual environment, in many respects a complete contrast to Darwin who laboured very much in isolation. While Darwin pursued his own work with dogged determination against the will of the Church in Britain, Haeckel did the very same in Germany and throughout Europe, often staging elaborate touring shows (*see photo above*) in which he presented arguments that were then considered to be heretical (and by some still are).



Charles Robert Darwin, aged 40
(Lithograph by Thomas Herbert Maguire, 1849)

Examination of the significant correspondence between Haeckel and Darwin provides evidence that these men became close friends, who clearly and deeply understood both their own cultural landscape and that of each other. It may have been this very understanding and mutual respect that allowed the arguments about evolution to flourish in both Britain and Germany, as both men used the other's position as a lever, or perhaps even as a convenient excuse to introduce ideas that they knew to be controversial and difficult for their own society to accept. Either way, the relationship between the two appears to have accelerated the discussion to the point of wide recognition in both countries and beyond.

In Germany the morphologist movement was active in describing and defining the process of change in biology. The morphologists included notable German scholars such as Goethe and Alexander von Humboldt, and of course, Haeckel. They believed that species form was not fixed, but that it changed towards some predetermined form over time. This concept, in the scientific literature, is referred to as transcendentalism. At that time, this new and radical ideology posed a number of questions, the most significant of which were:

How was the eventual form coded?

What process drove the change?

In what form did the process start?

These questions were hotly debated and drew on occasions sharp dividing lines between German scientists, and also brought along understandable tensions between their scientific promoters and the established Church. The morphologists' view that the eventual end of the development would be some perfect form appeared to be acceptable at some level to the Church, providing the evolution of mankind was kept out of the discussion! The main issue was how or when the design originated. The widely accepted view at the time was that the blueprint was coded into the species at the time of creation. In many respects, if you accept the act of creation by some infinitely wise deity, as did the overwhelming majority of scientists of the era, then this perhaps is a perfectly reasonable explanation. Some, however, were not prepared to accept the idea that life began at the whim of a divine Creator. Huxley and Haeckel were particularly vocal members of this group. They thought, or were at least moving towards thinking, that the initial formation of living material was a purely chemical event. Not only was such a notion sharply at variance with the basic tenets of the western religions, it also ran contrary to the longstanding vitalistic theory. Vitalism took on a number of guises; most relevant here was the then prevailing notion that living organisms were fundamentally different from non-living entities because some mystical vital spark (*élan vital*) was breathed into them in the act of their creation. Importantly, this extended to their organic products, so that the synthesis of organic compounds from inorganic constituents was, as a consequence, impossible. The accidental synthesis of urea in 1828 from wholly inorganic reactants by the German chemist Friedrich Wöhler in principle repudiated this, although it seems to have had very limited impact at the time. However, the point was made and so, if required, provided a basis with which to counter the vitalistic perception that life relied upon the act of divine creation. Removing the need for the divine creation of species brought with it a fundamental problem for the morphologists: how did the different codes for the great variety of proposed perfect forms for extant species arise?

Then, indirectly, into this ferment, in the summer of 1860, a bombshell arrived from quiet rural Kent: Darwin's *Origin of Species*, published the previous year, was translated into German by Heinrich Bronn. It basically and succinctly provided answers to two of the three questions that the morphologists' theory gave rise to, namely:

The process that drove change was the species' response to an ever-changing environment.

There was no code for a final form, the process itself defined what lived and thrived and what was 'fit' (literally and figuratively) for contemporary prevailing circumstance.

However, it did not answer the third and contentious question: In what form did the process start? According to Robert Richards, Bronn in his translation dropped Darwin's sentence 'Light will be thrown on the origin of man and his history'. Bronn, like others in the German scientific community, was not wholly convinced by Darwin's thesis and the debate rumbled on in Germany, as elsewhere, through the remainder of the century. Haeckel however grasped the concept and ran with it with the force of a rugby second-row forward.

A brief history of the man

Haeckel was born in 1834 in Potsdam (then in Prussia) to an upper middle class family, and christened Ernst Heinrich Philipp August Haeckel. His father was a jurist who served as privy councillor to the Prussian Court. His parents had ambitions for him to take up a medical career, and in 1852 he was sent to study in Würzburg, the Medical Faculty at the University being the pre-eminent in Germany at that time. There he was taught by two influential educators, Albert von Kölliker and Rudolf Virchow, who both communicated careful observation as a mode of learning, rather than absorbing by rote, a practice that was all too common in that era. Some decades later, Haeckel fell out with Virchow over the latter's concerns surrounding the dangers of teaching evolution to the 'untutored' mind. Haeckel strongly challenged this view and argued for the teaching of evolution to be introduced into the lower school curriculum – his British counterpart Huxley was involved in much the same discussion. The debate over the teaching of creationism and evolution still rages – *plus ça change, plus c'est la même chose*.

Although Haeckel was inspired by his teachers he had no wish to become a physician, and much of his spare time during his undergraduate years was spent reading the works of Kant and Goethe, leaders in the fevered German philosophical landscape of the time. He was also drawn by the accounts of the travels of Alexander von Humboldt and Darwin, and his great ambition became to follow their example. In 1856, after a gruelling part of his medical course, Ernst took off to the French Riviera where he languished in an idyllic world, only to later be brought back to Berlin, and the reality of medical studies, by a concerned father. Haeckel duly completed his medical studies in March 1857. He planned to begin a study of science in Berlin under Johannes Müller, but Müller's death meant a change of plan, and he instead moved to Jena, where Karl Gegenbaur was the Professor of Anatomy. Gegenbaur became a great inspiration to Haeckel, and also a life-long and stalwart friend. Late in 1858, he invited Haeckel to join him on fieldwork in Naples. This, after a false start, was a turning point in his career. Gegenbaur had to withdraw from the field trip, so Haeckel set off alone and in the spring of 1859 set himself up in Naples where he received benthic samples from local fishermen. However, he felt that he was making no progress and after a couple of months abandoned the work and departed to the nearby island of Ischia. There he met Herman Allmers, a poet and painter, and through the summer the two became soul mates, enjoying a Bohemian lifestyle, eventually moving to Messina, via Capri (*see above right*).

Allmers had to depart in mid-October and so Haeckel turned back to his original purpose, that of collecting, categorising and cataloguing marine specimens. Here came the breakthrough which Haeckel seized with both hands. In November, the samples began to contain radiolarians: this became the pivotal moment that cast the die for his future career. Over the next few months he described some 100 new species of radiolarians, and the following April he returned to Jena with 12 crates of samples and began preparing to work on the collection for his Habilitation (the German licence to take on and teach students at a university). He successfully presented the work in 1861, in Latin.

While Haeckel is known to have read Darwin's *Origin of Species*, he apparently made no reference to it in this initial work. Robert Richards, Haeckel's biographer, surmises that this may reflect caution, unusual in Haeckel's case, as Darwin's theory was then probably still regarded with scepticism by influential scientists in the German community. The following year Haeckel published the two-volume *Die Radiolarien*, and in this he incorporated Darwin's ideas on evolution into the discussions. It was some 672 pages in length with 35 beautiful and skilfully drawn images, engraved onto copper plates for printing. Richards, in his biography of Haeckel (see Further reading), describes how he made careful measurements and then made models using potatoes with rods skewered into them so he could get the correct perspective for the final drawing.

Haeckel's watercolour of Capri, painted in 1859

Haeckel's science

Haeckel's total output was colossal, as diverse as it was extensive. Four works stand out as milestones: *Natürliche Schöpfungsgeschichte* (1868), three of the four Volumes he prepared for the reports of the HMS *Challenger* Expedition (1882–88), *Kunstformen der Natur* (published as a series of lithographs over the period 1899 to 1904) and *Die Welträthsel* (1899), all profoundly different in nature and content. Following his Habilitation in 1861 for his work on radiolarians, Haeckel's scientific career can be considered as three distinct phases.

1866–1879: Intensive output of major texts covering a wide range of topics including, and tying together, morphology, evolution and embryology.

1879–1889: Taxonomic work, notably the analysis of samples from the *Challenger* Expedition.

1899 onwards: Work of generally wider public interest.

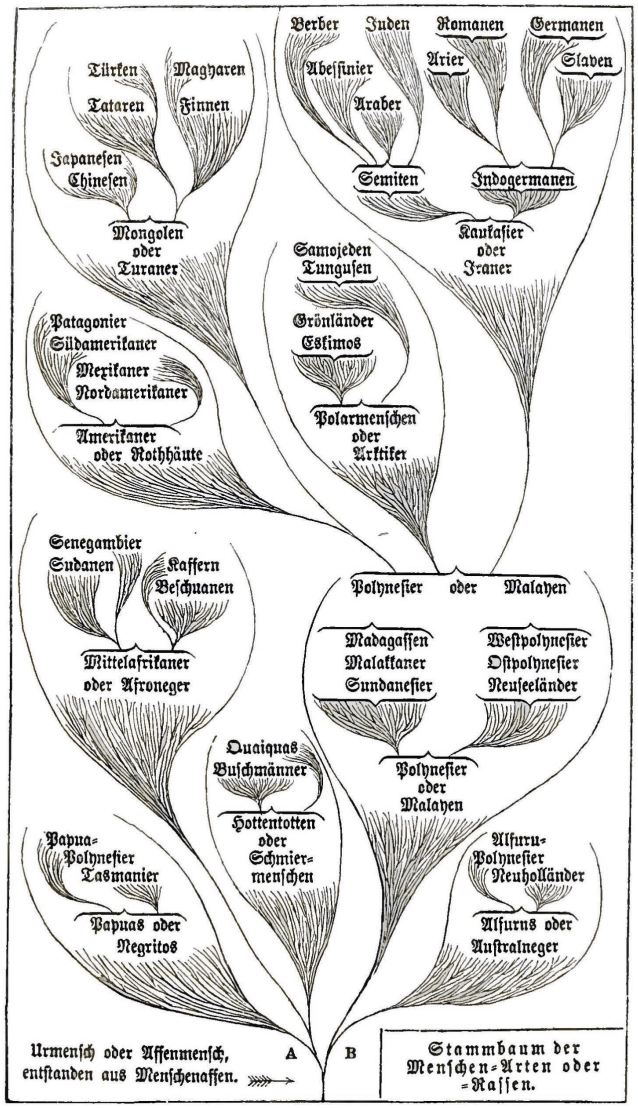
Haeckel's original sketch of the radiolarian* Rhizosphaera trigonacantha, *which appears in his 1862 publication* Der Radiolarien, *as part of Plate 25

1866 to 1879

Natürliche Schöpfungsgeschichte (*The Natural History of Creation*) had been preceded in 1866 by *Generelle Morphologie der Organismen*, which was an extensive two-volume text, a shade over 1000 pages long, written in just 12 months following the sudden death of Anna, his young wife. The work was not widely read, and to some extent *Natürliche Schöpfungsgeschichte* was written to remedy this. The book was translated into English as the *History of Creation* (1884), the word 'Natural' being omitted from the title, apparently at the suggestion of the English zoologist Ray Lankester in order 'not to frighten the pious English'. The book dealt with Darwinian and Lamarkian evolutionary theories, among a host of other topics.

Darwin developed his thoughts on the evolutionary mechanism in large part from animal breeding, with some supporting evidence from palaeontology, although that subject was in its infancy during his time. Haeckel added a further strand by introducing evidence from embryology. A major principle that Haeckel brought forward was what he referred to as the Biogenetic Law, better known by the catchphrase 'ontogeny recapitulates phylogeny'. The principle maintains that the embryo progresses through a series of developmental stages similar to that which the species has encountered during its own evolution. Although the validity of the concept continues to be debated, in the broad sense, Haeckel's fundamental point that there are important similarities between different vertebrate embryos is now known to be correct. As we will discuss later, the way Haeckel handled the matter got him, and the concept, into pretty hot water.

Haeckel's stem tree of the nine human races, with their varieties and the ape man at the source
From Natürliche Schöpfungsgeschichte *(1868)*



Darwin and Haeckel, along with other scientists of the time, argued passionately for the concept of evolution of species. Inevitably, if this general principle is accepted, one has to confront the problem of evolution in the case of man, clearly a potentially inflammatory issue. However, Haeckel with his longstanding preoccupation with patterns and his somewhat reckless nature, marched into this without much caution. He placed the various races of *Homo sapiens* into the same type of structure that he used so well to define the relationship between other forms of life. In his normal usage of the dendrographic stem tree, the extant species are the twigs at the end of the branches and not intermediates in the evolutionary process. However, his figure (*left*) can be read a number of ways and there is no shortage of critics who saw the diagram as an evolutionary ranking of contemporary races of man.

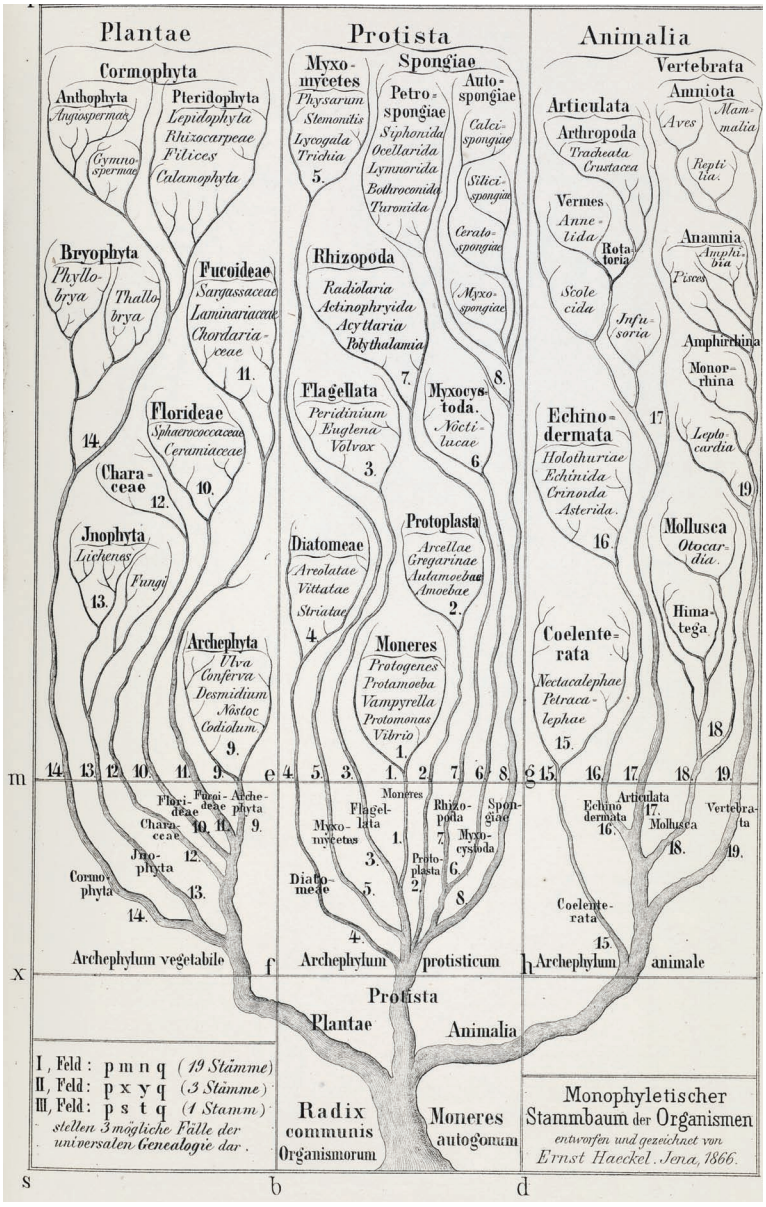
Haeckel blundered into a further and even more contentious area. Artificial selection of progeny was to a large extent used by Darwin to give insight into natural selection. Haeckel attempted to illustrate this in the case of man by attributing the legendary vigour of the Spartans and the North American Indians to their supposed practice of killing deformed and defective newborns. This in turn led to accusations that Haeckel, and to a lesser extent Darwin, laid down the racist philosophy of the Nazis which gave rise to the holocaust. There are associated claims that Haeckel was profoundly anti-Semitic. Equally strong counter-claims are made of Haeckel's positive attitude towards the Jewish intellectual community. The problem one faces with these controversies is that Haeckel wrote so much, on such diverse matters, and in such a frank style, that

it is possible to construct almost any view from his words. However, reading *Die Welträthsel*, which he regarded as a summary of his philosophies (*see later*), one is not left with an impression that it is the writings of a racist.

The three 'sandals'

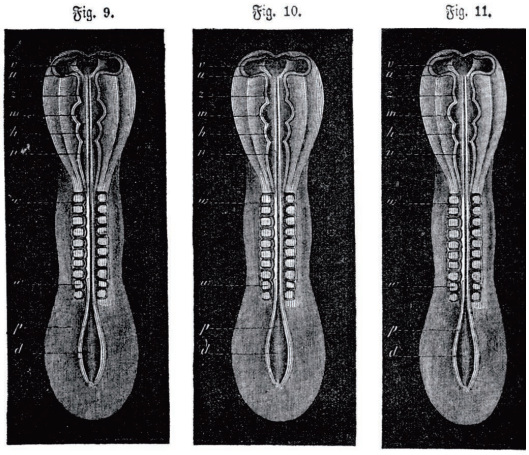
Haeckel had a lifelong interest in patterns and it links his art and science. While the elasticity of comparing patterns does not always sit comfortably with the more rigid principles of science, it very much appealed to him. There is in embryology and other areas of morphology no fixed image, rather a spectrum of forms, and thus considerable scope for selection and adjustment of proportions and detail that can simplify the telling of the tale. Haeckel operated, apparently comfortably, on this fuzzy boundary. There is a division of opinion as to how often, and to what extent, he could be found, from a scientific standpoint, operating on the wrong side of the boundary. In the first edition of *Natürliche Schöpfungsgeschichte* he was clearly caught where he should not have been. In putting together the arguments in support of his Biogenetic Law he showed images of an early developmental stage – the so called 'sandal' stage – of three vertebrates: the dog, chicken and turtle. The attendant comment in the text ran: 'If you compare the young embryos … you will not be in a position to perceive a difference'. Although the three images were claimed by Haeckel to be from the three quite different vertebrates, they were in fact electrotype copies made from of a single woodcut. It was an outrageous piece of folly as it was clear that it would be spotted, and it was almost immediately by Ludwig Rütimeyer, an anatomist at Basel University. Rütimeyer clearly could not resist observing that indeed you would not be able to discern any difference as they were in fact the same image. In the following edition of *Natürliche Schöpfungsgeschichte* Haeckel replaced the three images with a single image along with the statement that 'It is all the same whether we describe the embryo of the dog, chicken or turtle, or any other of the higher vertebrates. For the embryos ... at the represented stage cannot be distinguished' – not a *mea culpa* by any measure. However, much later, in 1891, he did recognise his folly, which he referred to as 'a highly rash kind of madness'.

In addition to the 'three sandals', there are other subtle and debateable liberties with embryo images pointed out by scientists who were not prepared to buy into Haeckel's Biogenetic Law, and there was no shortage of them in Germany alone. Foremost amongst his critics was Wilhelm His, Professor of Anatomy and Physiology at the University of Basel. Without doubt His had an agenda. He held a totally different view of the mechanism of embryo development from that portrayed by Haeckel – one that did not fit with the Biogenic Law – so would have been anxious to discredit it. Further, in common with embryologists of the time, His was very protective of his turf, regarding embryology as a closed shop, and certainly intrusions by non-card-carrying gadflies, such as Haeckel, were not to be welcomed.



Haeckel's three-branched phylogenetic tree, with his new branch for Protista

Although Haeckel had made some amendments to his initial claims, and although further research has implied he was probably more right than wrong, the damage was done and accusation of fraud stayed with him and is maintained by some to this day. A remarkable example of efforts to proscribe Haeckel's work in modern times was a bill put forward to the Arkansas legislature in 2001. This proposed that it



***The three 'sandals' from the first edition of* Natürliche Schöpfungsgeschichte**

should be illegal for the state or any of its agencies to use state funds to purchase for schools or libraries books that contain false or fraudulent claims. Haeckel appears on the list. In addition there is a piece of folklore, much cycled in the Creationist literature, that in 1874 Haeckel was tried and found guilty of fraud by a court of his peers at Jena University. Richards, in his scholarly biography of Haeckel, reports that there is absolutely no evidence for this, and arguments to the contrary would appear to be pure sophistry.

Following the publication of *Natürliche Schöpfungsgeschichte*, Haeckel continued his study of embryology focussing on the calcareous sponges, and in particular the process of blastula* formation. This research was extensive, and beautifully detailed in a multivolume work – *Die Kalkschwämme*.

*A blastula is a sphere of cells produced during the development of an embryo.

1879 to 1889

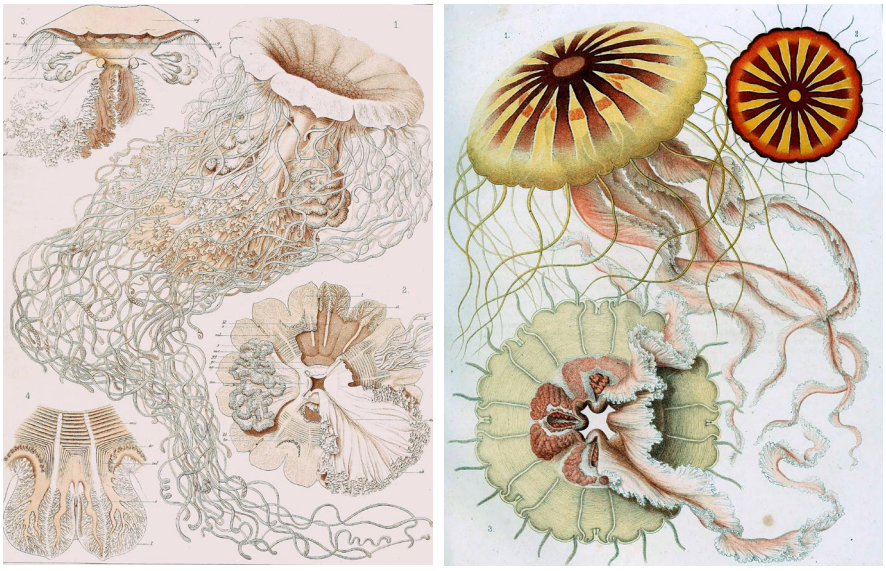
At some point, presumably in the late 1870s, Haeckel was invited to prepare reports for four collections of marine organisms acquired during the 1872–76 *Challenger* Expedition. In addition to his great love, the radiolarians, the collection included samples of deep-sea medusa, a related group – the siphonophores – and a group of sponges, the Keratosa. So far, we have been unable to locate the correspondence or any text covering the details of his brief. The articles appeared in the *Challenger Reports* over the period 1882 to 1889 and constituted the main part of Volume 4, and the complete Volumes 18, 28 and 32; they totalled some 2300 pages and 231 plates. The plates were lithographs prepared from sketches made by Haeckel, and the engraving and subsequent printing were undertaken by Eduard and Adolf Giltsch (father and son). The *Challenger Reports* contain by far the largest, and in many respects the finest, collection of plankton images made by Haeckel. Although a significant number of copies of the *Reports* were printed and distributed, their whereabouts is not well known or documented, and as a consequence the availability of images contained in them has been restricted to a privileged and informed few. In a move to make them more readily available, the images Haeckel drew for the *Reports* have been placed on the internet, and a selection of them, together with a back story, has been published by Prestel under the title *Art Forms from the Abyss* (*for more information, see the box at the end of the article*).

In the work Haeckel prepared for the *Reports*, the radiolarians accounted for nearly 90% of the text and two-thirds of the total set of plates. Haeckel described some 3000 new species of radiolarians. There are question marks over the validity of his classification – in part this is due to his primary separation of the group into four 'legions'; the consequence of this was that it gave rise to an excess of groupings at the lower taxonomic levels. Further, Haeckel was frequently presented with fragments of organisms for which he had to use his experience and imagination to assemble whole organisms – inevitably this gave rise to the creation of false forms. If we put this aside, and judge his images as they stand, the images of radiolarians are surely unique. A frequent comment from non-specialists is that they are unworldly, as indeed they are, for they are of another world – a world we share with them but understand poorly, and for which few have an intuitive feel – the world of the microorganism, quiet, minute, incredibly active and phenomenally powerful. The siphonophores are equally alien in their own way – almost creatures of a Tolkien world – inscrutable and threatening and, as with their cousins the medusa, their good looks mask a very nasty creature endowed with a powerful, and in the case of some medusa (e.g. the box jellyfish), a lethal sting.

1899 onwards

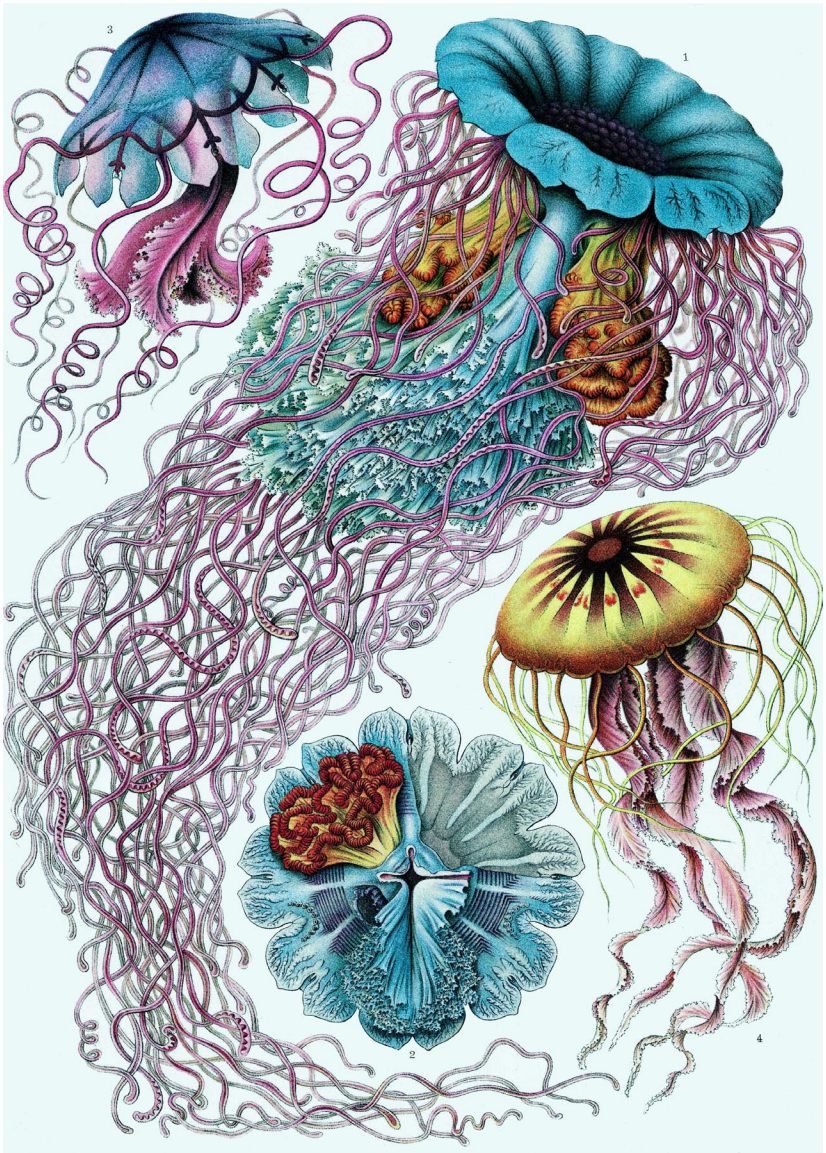
The late 1890s saw Haeckel turn to work of a wider public interest. In 1899, he began the publication of a series of lithographs, collected under the title of *Kunstformen der Natur (Art Forms in Nature)*. This drew extensively on his earlier published taxonomic studies on marine plankton, *Die Radiolarien* (1862) and *Das System der Medusen* (1879); the latter was the first in a series under the collective title *Monographie der Medusen*, a subsequent volume being published in 1881. He also drew upon the illustrations in the three volumes on planktonic groups he had prepared for the *Challenger Reports.* All of these were redrawn and re-assembled for the new publication. There were a number of reasons for this. The originals were created for a taxonomic text, whereas *Kunstformen der Natur* was targeted at a wholly different audience. Further, the limestone slabs from which the original lithographs had been printed would have been recycled, so inevitably new images would have had to be engraved. Haeckel used this as an opportunity to recast and reassemble his designs. Part of the correspondence between Haeckel and Adolf Giltsch has been preserved and it is evident from this that the Giltschs exploited the medium of lithography to its full. Haeckel's sketchbooks have also been preserved, and in the case of Haeckel's iconic image of the medusa *Desmonema* we have a visual record of its evolution *(see opposite*). The top left-hand panel shows the original sketch of *Desmonema* that Haeckel produced for the illustrator, and the adjacent panel shows Eduard Giltsch's published lithograph derived from it, plus his image of the medusa *Polybostrycha* (also named *Chrysaora*). These were published in 1879 as Plates 30 and 31 in *System der Medusen*. A decade later, when Haeckel began the lithographs that were to be gathered together in the series *Kunstformen der Natur*, he combined and redrew these two images (*lower left-hand panel*) as Plate 8 – in this case, the lithograph (*lower right*) was made by Adolf Giltsch. Thus, the final image named *Desmonema* is in fact a composite of two species of medusa.

Initial sketch of **Desmonema** *from Haeckel's notebook*



Lithographs (Plates 30 and 31) produced by Eduard Giltsch for System der Medusen, *published in 1879*

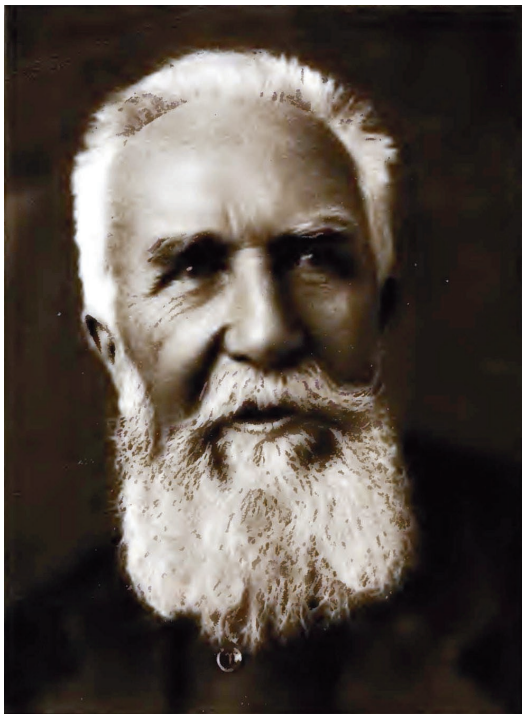
Revised layout by Haeckel combining Plates 30 and 31 for **Kunstformen der Natur**



Final combined iithograph of **Desmonena** *produced by Eduard Giltsch for* **Kunstformen der Natur**

Evolution of the iconic image of Desmonena

The images from *Kunstformen der Natur* have been used in a wide range of designs, from major architectural structures to table napkins. The image collection is still used in art schools as a source book. The full set of images from this work and those from *Die Radiolarien* have been published by Prestel under the titles *Art Forms in Nature* and *Art Forms from the Ocean*. The publication of *Art Forms from the Abyss* (the images produced for the *Challenger Reports*) all but completes the modern facsimiles of Haeckel's plankton images; there remain 40 images published in 1879, which form part of *System der Medusen*.



Photograph of Haeckel by Lichtkunst in* Was wir Ernst Haeckel verdanken *(What we owe to Ernst Haeckel), a series of essays published in 1914 to celebrate Haeckel's 80th birthday.

The same period of Haeckel's life, the turn of the 1800s, saw another significant product, *Die Welträthsel* (published in 1899), again directed at a wider public. The book was a phenomenal and unqualified success: it was published in September and there were two further printings before the year was out. 40 000 copies were sold in the first twelve months alone. The book was translated into English under the title *The Riddle of the Universe*. Even though it is now over 100 years since its first publication, it is still thought-provoking and eminently readable.

As seems inescapable with Haeckel, the book provoked controversy. He starts the book by laying down what he regards as two undisputed and fundamental laws of nature – the Law of Substance and the Law of Evolution – and from these he builds what he refers to as his monist philosophy. In brief, it contends that the cosmos, life included, contains just two basic things – energy and matter – and that there is no non-material component of living things. This, as much of the book, confronts a number of aspects of western religious doctrines head on). One issue he discusses at great length is the concept of the soul, devoting four chapters within the book to it. Haeckel does not deny the existence of the soul, but recasts it in an alternative form. The important distinction between Haeckel's notion and that of the western Church and other cultures, is that Haeckel saw the soul as an anatomical rather than a spiritual feature and one, moreover, that is present in all living organisms. From his materialist standpoint, he would not accept the soul as some immortal spiritual entity; he recasts it as a store of information and learning within the organism. He coins the term psychoplasm for the place where this information was stored in the cell; a notion he invented as there was no direct evidence for its existence. One could take the view that he has simply replaced one mystical entity for another; conversely one might argue that DNA and the genetic code are to some extent a latter-day realisation of this idea. As Mendel's work lay hidden until 1900, Haeckel, like Darwin, could have had no insight of hereditary mechanisms.

In the latter part of the book, Haeckel dwells on the matter of ethics, making the point that our code of ethics arose as a social survival instinct by a process of natural selection, and not from religious texts. A similar case has been made more recently by Richard Dawkins in his book *The God Delusion*. Haeckel berates the Christian Church for its failure to command the cherishing of Nature and its creatures – contrasting it with the teachings of Buddha. He also deplores the lack of guidance and practice of personal cleanliness by the Church of his time. Haeckel notes that man as a social animal survives by managing two duties: care of himself and that of his neighbour. Here Haeckel manages to ruffle a few (British) feathers. He argues that the flaw in the Christian ethic is that it exaggerates the love to be given to your neighbour over that of your kin. He notes the oft preached 'Love your enemies, bless them that curse you ...', which he argues leads on to 'If any man will take away your coat, let him have thy cloak also'; he continues in what he terms the language of modern politics: 'When the pious English take from you simple Germans one after the other your new and valuable colonies in Africa, let them have the rest of your colonies also or, best of all give them Germany itself.' That, not surprisingly, got up the nose of the British establishment, and may explain why although the British papers reported his death, none, as far as we are able to determine, provided an obituary.

Whatever you may make of Haeckel, he was, without the slightest doubt, a complex, outstandingly talented and multifaceted man. This article just scratches the surface of his life and persona. Our feelings are well summed up in the concluding paragraph of Nick Hopwood's scholarly analysis of Haeckel's embryo images which, although dealing with just one aspect of Haeckel's science,

makes points we would regard as having a general validity:

> Historical research can hardly expect to bridge the ideological chasm across which the recent controversy over Haeckel's illustrations has been fought out. But as well as unearthing and assessing evidence that all parties should take into account, it can show that if we only go beyond judging Haeckel to learn from the rich history of his plates, there are plenty of more productive questions to debate. Investigating further the fates of his pictures could help recover important dimensions of change since the 1870s. But the legitimacy of scientific images is still negotiated where didactic methods, research agendas, national politics, and science–religion disputes meet in media controversy. Paradoxically, it may be just as Haeckel's embryos are removed from textbooks that they have most to teach.'

Further Reading

Copies of essentially the full set of Haeckel's published work can be downloaded from the Biodiversity Heritage Library collection – the following link is to the full catalogue for Haeckel: http://www.biodiversitylibrary.org/search?searchTerm=Ernst+Haeckel#/titles. By far the best account of Haeckel's life and work is the scholarly biography by Robert J. Richards (*The Tragic Sense of Life – Ernst Haeckel and the Struggle over Evolutionary Thought*, 551pp., published by the University of Chicago Press) – we have drawn very heavily upon this account of Haeckel.

Second-hand copies of the English translation of *Die Welträthsel* (*The Riddle of the Universe at the Close of the Nineteenth Century*, to give the book its full title) can be found in the catalogues of various second-hand booksellers, and pdfs can be downloaded from a number of sites. This book gives an insight into Haeckel's views on science, nature and philosophy. An extensive analysis of Haeckel's use and misuse of images, *Haeckel's Embryos: Images, Evolution and Fraud* by Nick Hopwood (392pp., 2015) has been published by the University of Chicago Press. The accusations of Haeckel's racism and anti-semitism, and aspects of Nazism philosophy that can be attributed to him, are described in the book *Haeckel's Monism and the Birth of Fascist Ideology* by David Gasman (482pp., published by Peter Lang, 1998). Critical analyses of Gasman's arguments on Haeckel's purported racism have been made by Richard Richards and are available on the internet: 'Myth 19: That Darwin and Haeckel were complicit in Nazi biology' http://home.uchicago.edu/~rjr6/articles/Myth.pdf, and 'Ernst Haeckel's alleged anti-semitism and contributions to Nazi biology' http://home.uchicago.edu/rjr6/articles/Haeckel--antiSemitism.pdf.

Acknowledgements

We thank the publisher Prestel for permission to use the images of the Jena theatre, Haeckel's painting of Capri and the reproduction of the radiolarian image from Haeckel's sketchbook – all taken from their publication *Visions of Nature* by Olaf Breidback. The images illustrating the evolution of Haeckel's iconic *Desmonema* composite have been taken from Prestel's publication *Art Forms from the Abyss.* The portraits of Goethe and Darwin, and Haeckel's three-branched dendrogram, have been downloaded with permission from the Wellcome Image Library. We are indebted to Professor Chris Richardson for a very thorough reading of the final draft of this article.

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Peter J. L. Williams has retired from Bangor University, but not from oceanography. Retirement has enabled him to spend more time on other interests, including designing and building stage sets for a local amateur dramatic society. He has also put together two exhibitions on the influence of plankton illustrations in art and design.

Haeckel's Art Made Available to All

In a move to make Haeckel's beautiful images more readily available, a group of Haeckel enthusiasts from Bangor University have put together high-quality images of the illustrations of medusa, siphonophores and radiolarians which Haeckel drew for the *Challenger Reports*. They can be viewed on the internet at http://haeckel.bangor.ac.uk/. This work was undertaken with the help of a grant from the Challenger Society. Some 55 of the images, along with a back story, have been published by Prestel under the title *Art Forms from the Abyss,* which will sit alongside *Art Forms from the Ocean* and *Art Forms from Nature,* also published by Prestel. For more information about these books see overleaf.