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What do you mean by a lie?

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Haeckel's Embryos: Images, Evolution and Fraud by Nick Hopwood
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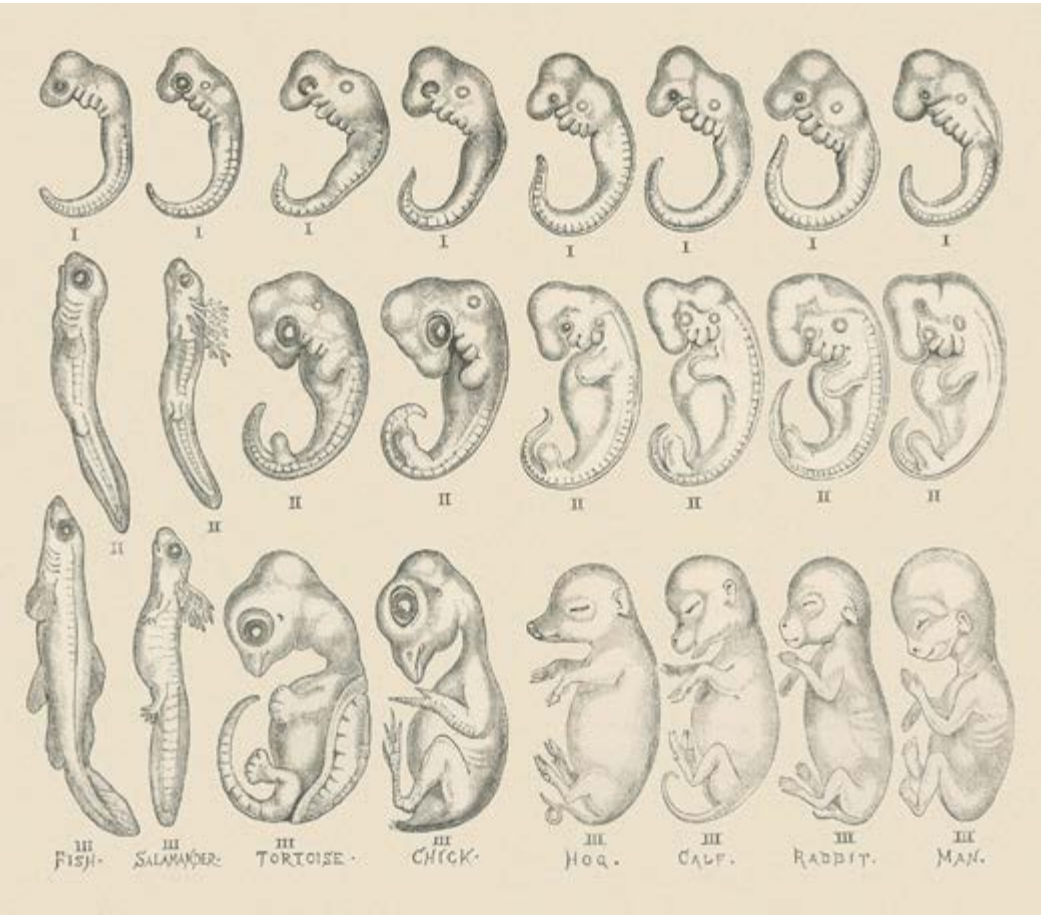
Some generalisations about the natural world are easy to recall because they are expressed in apothegms – concise, rhetorically marked-out sayings that stick in the mind and come easily to the tongue. Whatever goes up must come down; for every action, there's an equal and opposite reaction; all life from pre-existing life; all cells from pre-existing cells; the angle of incidence is equal to the angle of reflection; energy can neither be created nor destroyed.



Then there are scientific principles whose mnemonic power, meanings and implications for future inquiry come in part not from words but from images – two-dimensional pictures or

three-dimensional models. Consider the relationship between the Tree of Life and 19th-century understandings of species change; the Great Chain of Being and medieval ideas of plenitude; or Leonardo’s Vitruvian Man and Renaissance notions of microcosm and macrocosm. The orrery was an 18th-century mechanical model of the solar system that showed, at a glance and without equations, how the motions of one celestial body related to those of others. The ‘Rutherford atom’ – electrons orbiting a central nucleus – summons up both a theory of atomic structure and the powers of nuclear energy. The periodic table made visible ideas of the connection between atomic weight and the periodicity of chemical properties. Watson and Crick took one look at the first jerry-rigged workshop model of double-helical DNA and they saw how the structure might account for both genetic coding and genetic function.

There are only a few scientific principles that enjoy both advantages – the sticky-linguistic and the sticky-visual. Even if you aren’t a biologist, there’s a chance you will have heard the saying ‘ontogeny recapitulates phylogeny’: the claim that the growth and development of an individual from conception to maturity repeats the evolutionary history of the species, that embryological development passes through the adult forms of species in its evolutionary lineage. The human embryo, for example, starts out looking like an invertebrate, then like a fish, then takes on generic mammalian characteristics, then an ape-like appearance, and only finally comes to resemble a human being. If you Google the phrase ‘ontogeny recapitulates phylogeny’, or its shorthand form ‘the biogenetic law’, you will probably be told four things: that its author was the biologist Ernst Haeckel (1834-1919); that it was introduced as a key feature of German Darwinism; that it is now discredited or in need of serious qualification; and that its articulation in the 1860s and 1870s was surrounded with controversy and accusations of serious bad behaviour. Then it’s likely you’ll be shown a version of a picture produced by Haeckel which makes the biogenetic law visible and which impresses its meaning more vividly than language could ever do. As Nick Hopwood shows, this picture persists in present-day scientific discussions despite of – and in many cases because of – its being faulty or even fraudulent.

The original version of the most famous of Haeckel’s embryo pictures was a woodcut spread across two pages of a book from 1868 grandly titled *Natürliche Schöpfungsgeschichte* (translated as *The History of Creation*). But the version that eventually became most iconic, and most controversial, appeared in a book from 1874 called *Anthropogenie* (translated as *The Evolution of Man*). This was a grid, containing 24 woodcut images of embryos at progressive stages of development. This grid was continually reworked and elaborated throughout Haeckel’s publishing career, and there were many related images, so there is no single stable representation but a series, more or less thickly populated with examples from different species, with more or less detail, produced using various technologies – Haeckel’s drawings were given to others to be turned into wood-block and copper engravings and lithographs. They were accompanied by different textual glosses but they were all enlisted in

the same basic scientific and philosophical cause. Hopwood’s book is a richly illustrated and staggeringly detailed story of how Haeckel’s embryo pictures came to be, how they were mobilised as resources in scientific and ideological causes, how versions of the grid picture were copied, recopied and modified, how their accuracy was vigorously disputed by some and defended by others, and how they continue to circulate – still relevant and still contentious – today.

The juxtaposition of embryos in graphic space can be a visual argument for their succession in time and for the causal relations between them. Hopwood notes that graphic series were not common in scientific imagery before this – perhaps the best-known instance is T.H. Huxley’s much copied and often spoofed 1863 series of five skeletons, lined up and increasing in height, from the gibbon at the left, through orangutan, chimp and gorilla, to the human being at the right. A double series, like Haeckel’s grid, was rarer still. The two modes of juxtaposition in the grid represent two scales of time and the biological relationships between organisms in each scale. The top row – from left to right – shows early embryos of eight different species: fish, salamander, turtle, chicken, pig, cow, rabbit and human being. The columns, from top to bottom, depict the embryological development of individuals of each species (their ontogeny), where you are meant to understand that the embryos shown are representative of how development goes for the species, not just for any individual chicken or cow. The columns chart developmental time: stages in the days-to-months scale in which an organism goes from fertilised egg to birth or hatching. The rows show embryos from different species at ‘equivalent’ developmental stages, though in one species this might be days after fertilisation and in another months. The rows also call on existing understandings of the timescales of life on earth – many thousands to millions of years – and of the historical relationship between species. The presumption is that we already possess, as a matter of course, some of the conceptual meaning of the left-to-right series – for example, that fish and reptiles are ‘lower’ forms than mammals like pigs and rabbits, and that human beings, at the far right, are the ‘highest’ form. The image is just ink on paper, but it is multiply dynamic, conceptually complex, culturally resonant and ideologically loaded.

Darwin did find a place for embryological evidence towards the very end of the *Origin of Species*, but the major supports for his theory of evolution by natural selection were provided by fossil evidence, by assembled facts about the distribution of species in space, by logical deduction from the twin principles of heritable variation and the struggle for existence, and by metaphorical extension from the results of ‘artificial selection’ in domestic breeding. There was only a single image in the first edition of *Origin* – a branching diagram purporting to illustrate how dissimilar species might evolve from a common ancestor – and little sense that the credibility of evolution might be secured by a pictorial comparison of the embryological development of different species. But this was just what Haeckel’s embryo images aimed to do. If embryology could be made lawful, clear and visible, there was, Haeckel claimed, no more powerful argument for evolution. In Hopwood’s summary of

Haeckel’s ambition, ‘ontogeny was more remarkable than phylogeny, yet occurred every day’: the facts of embryology were ‘sufficient to prove [evolutionary] theory by themselves’. Early in development, there are, Haeckel maintained, no significant differences between species; the differences appear only later on. The evident fact that our embryological development goes through a fish-like stage is offered as proof that fish are in our evolutionary lineage.

Pictures and propositions belong to different representational orders and in any culture that models knowing on seeing, images invite strong identification with the thing they depict. ‘The iconography of persuasion strikes even closer than words to the core of our being,’ the evolutionary biologist Stephen Jay Gould once said. Scientists use pictures more than most academics, but ‘somewhere along the way’, he cautioned, they have lost the sense that it’s wrong to identify pictures with the realities they represent. We say that we ‘see’ a four-week dog embryo when what we are looking at is, of course, somebody’s picture of it, the making of which typically draws on a range of representational conventions and the technologies, skills, purposes and constraints of different sorts of people: scientists, artists, engravers and other skilled picture-makers, printers, publishers. For all that, showing can indeed be more persuasive than saying. You might qualify a scientific proposition with ‘possibly’ and ‘probably’, but a picture is presented without qualifications other than any contained in the textual gloss. This means that pictures have power not just to represent reality but, with equal power, to lead you astray.

Images can have politics, and Haeckel’s embryos circulated in several political domains. Embryology wasn’t a popular subject in 19th-century German universities. It had few practical uses, and at a time when all the bright young scientists in Germany were turning to hard-nosed experimental and physiological approaches, it was dismissed as a merely ‘descriptive’ discipline. But even description wasn’t easy. Source materials were scarce, hard to handle, hard or impossible to experiment on. It was difficult to arrange specimens in developmental series – even to know how old they were – especially in the case of mammals, and human beings in particular. If you wanted to know how old a human embryo was, you depended on a woman’s knowledge of the moment of conception, and that knowledge might be unreliable or unattainable.

In this context, pictures had an important role in pedagogy. They represented what an expert had seen but also instructed students about how they *should* see, and represent what they’d seen. (The originals of many of Haeckel’s published pictures may have been wall-charts used in classrooms and public demonstrations: that’s one reason they look like they do.) Specialist students were expected to look at embryos themselves – they were by Haeckel’s time beginning to make serious use of microscopy – but for educated laypeople printed pictures were the only source of relevant visual experience. They might have the misfortune to encounter a chick embryo in an egg at breakfast, but mammalian development from fertilised egg to birth took place out of view. Mammals’ eggs are tiny compared to those of, say, chickens or reptiles: at about 100μm in diameter, they are barely visible to the naked eye

and in short supply compared to the wholesale egg production of birds, fish and reptiles.

Well into the 19th century, according to Haeckel, most educated Germans lived in blissful ignorance of the facts: they ‘do not even know that each human individual is developed from an egg, and that this egg is a simple cell, like that of any animal or plant’. The facts of human development, as revealed in Haeckel’s popular books, may have come as a shock to people who maintained a belief in the biological uniqueness of human beings. There was distaste too. Human embryos ended up in the laboratory as a result of miscarriages, abortions or the death of pregnant women. Many saw Haeckel’s embryos as ‘dirty pictures’, too close to death, but also too close to the sexual origins of life. Even as late as the early 20th century, the *New York Times*’s review of *The Evolution of Man* warned that ‘the subject is rather gruesome, and is not best adapted for public discussion.’ Nonetheless, Hopwood offers reports of boys making a furtive study of Haeckel’s pictures of human embryos, and progressive-minded women embracing *The History of Creation*, and especially its pictures, as ‘forbidden knowledge’, a resource for sexual liberation. Haeckel had taught the world ‘the facts of life’.

Haeckel read the *Origin of Species* just after its translation into German and fell instantly in love with Darwin. When he visited Down House several years later to pay homage, Darwin complained mildly about Haeckel’s portentousness and bellowing, but it was the German who became the world’s most influential ‘Darwinist’. (The historian Robert Richards has written that before the First World War more people learned of evolutionary theory through Haeckel’s publications than through any other source, even if Haeckel’s *Darwinismus* was a proprietary blend of the *Origin*’s natural selection, Lamarck’s evolution through the effects of use and disuse, the metaphysics of Goethe and German *Naturphilosophie*.) Darwin knew he was being flattered, but was confused and anxious about Haeckel’s ambition to establish evolution as the final solution to all remaining scientific, philosophical, political, aesthetic and religious problems. So Haeckel instructed the world on the ‘meaning of life’ as well as its facts: the secrets of the origins of life, motion, sensation, consciousness, rational thought and language; the nature and bases of beauty; the grand illusion of free will; and how to build a curriculum on the foundation of scientific materialism. ‘Your boldness,’ Darwin wrote to Haeckel in 1868, ‘sometimes makes me tremble.’

Haeckel aggressively marketed a ‘Monism’ in which there was no place for any dualism between matter and spirit; he didn’t formally deny God but identified Him with Nature itself. There was, he asserted, ‘no miracle, no creation, no creator’. He associated *Darwinismus* with the anticlerical forces of Bismarck’s *Kulturkampf* of the 1870s, asserting that the natural ‘law of progress’ applied to the political realm too. The fact that we are descended from lower animal forms, and that as embryos we are indistinguishable from our humble organic ancestors, might discomfit the average person, but it was – and ought to be – far more unsettling to the aristocracy. What would they ‘think of the thoroughbred blood which flows in their privileged veins, when they learn that all human embryos, those of nobles as well as commoners, during the first two months of development, are scarcely distinguishable from

the tailed embryos of the dog and other mammals?’

Evolutionism in Haeckel’s mode, Hopwood writes, ‘would rival Marxism in the ideology of German social democracy’. Engels had serious reservations about the intellectual quality of Haeckel’s materialism, but his confidence in the scientific lawfulness of human society was an index of Haeckel’s influence. Other German Marxists pushed Haeckelian embryology, and the Christian and conservative opposition pushed back, claiming that ‘Haeckel-Darwinism’ would breed up ‘a generation whose confessions are atheism and nihilism and whose political philosophy is communism’. Even some of Haeckel’s fellow scientists – who might otherwise have been intellectual allies – were disturbed by the sweep and grandiosity of his philosophy, worrying that Haeckel was overstepping the proper limits of natural science and was, as Hopwood says, ‘replacing religious with scientific metaphysics’. As science became more specialised, so scientists became less at ease with Haeckel’s style. Few scientists of his time, Hopwood says, ‘so mixed infamy with renown’.

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Haeckel was a talented and imaginative artist, in an era when skill in drawing and painting was still expected of many sorts of scientists. Indeed, the gorgeous, spectacularly coloured illustrations of plant and animal species – mainly invertebrates – in his turn of the century *Kunstformen der Natur* (*Art Forms in Nature*) were offered as visual evidence of the beautiful symmetrical organisational patterns present in nature, and influenced a generation of Art Nouveau designers and artists. But Haeckel’s aesthetic sensibilities, his pictorial flair, the frankness of his intention to engage the audience’s emotions as well as its intellects, and his use of images as arguments for an all-inclusive philosophy of nature, encouraged scientists to inspect his pictures with more than customary care. Did they count as scientific representations, or were they better thought of as artistic and metaphysical imaginings?

The first scientist to have a go at Haeckel’s images was a Swiss anatomist who maintained that controversial evolutionary claims ought to be supported by pictures scrupulously drawn from real-life specimens. Copying already published images was a widely accepted practice, but he caught Haeckel doing something which was not. In the *Schöpfungsgeschichte*, Haeckel asserted that early embryos of distantly related species could not by any means be distinguished and that, at later stages, there might be no way of distinguishing the embryos of different vertebrate species. Here was solid proof of common descent. Some version of that claim was standard in mid-19th century biology – Darwin included – but Haeckel had demonstrably given reality some illegitimate assistance. He had twice used the same woodblock engraving to represent the eggs and early embryos of three different species, in one case to represent the eggs of dog, ape and human being, in the other the embryonic forms of dog, chicken and turtle at the so-called ‘sandal stage’. Haeckel recognised the charge as a fair cop, and wasted little time in confessing. In the next edition of the book, he admitted to his ‘extremely rash *foolishness*’, but said there had been no intention to deceive – a

judgment that Hopwood joins other recent historians in endorsing. After all, a claim of no difference was very like one of great similarity or of no essential difference, and Haeckel’s critics didn’t contest the similar appearance of the early embryos of higher vertebrates.

In the 1870s another charge was levelled at Haeckel by the Leipzig anatomist Wilhelm His, one that requires more sensitive interpretation. The accusation was that Haeckel’s pictures were *schematic*: that they did not truthfully represent concrete realities but were illustrations of types – not unique individuals but essences, composites or representations of an inferred underlying pattern in nature that wasn’t visible in particular embryos. There was too much of the artist and the active thinker in them and too little of the naturalist, faithfully recording what was in front of his eyes. Even where Haeckel copied from other credible scientists, he was charged with cleaning up and adapting their images to fit his evolutionary theories, making some structures rather longer, some rather shorter, some more and some less pronounced than in the originals. Other embryonic features were, it was said, conjured into existence because they fitted Haeckel’s expectations on the basis of his biogenetic law. This was no longer copying; it was invention.

Several historians have recently recruited the Haeckel/His dispute in a sweeping story about historically shifting notions of objectivity. Haeckel, it is argued, adhered to a conception of truth-to-nature – where that ‘truth’ might require setting aside the accidents and contingencies of individual organisms or structures in favour of some notion of types, schematically rendered. His, on the other hand, adhered to an emerging conception of ‘mechanical objectivity’, modelled on and sometimes using novel instruments for the passive recording of natural realities, thereby placing limits on the potential for distortion in human intervention. The photograph, for example, was taken to represent particular realities as they actually were: the camera was a technology for securing this mechanical objectivity.

Hopwood isn’t alone among modern historians in having reservations about this story. It’s true that different conceptions of objectivity, and different notions of scientific truth, can be distinguished (not just in 19th-century science), and that there was suspicion of the active role of the intellect in representing natural things. But it isn’t right to say that one notion of objectivity neatly succeeded the other, or that His (and other critics of Haeckel) saw no legitimacy in schematic representations, or that Haeckel himself couldn’t offer a robust defence of schematic representation. Schematic images were, and remain, well suited to pedagogical and demonstrative purposes, where you might want to ‘make a point’ whose legitimacy is assured on other grounds, or train students to make out structures difficult to discern in messy specimens or in photographs. (His himself conceded such a role for schematic representations.) True, by the early 20th century it was common for Haeckel’s critics to compare his schematic pictures with what could be revealed by photographs, some saying that the availability of photographs would have settled Haeckel’s guilt, others that photographs would have made Haeckel’s case ‘far *better* and more convincingly’. But what was at issue was not the scientific legitimacy of ‘truth-to-nature’ versus ‘mechanical

objectivity’ but the specific conception of natural reality that different images were enlisted to establish. Objectivity as a methodological virtue can’t easily be disentangled from existing views of what counts as a scientific object and what counts as scientific knowledge.

His’s charges were serious, and were taken seriously, but they didn’t circulate much beyond the boundaries of the German scientific community and weren’t widely known abroad. There were whispers of ‘fraud’ and ‘forgery’, but little more than that. What changed things was the blockbuster success at the turn of the century of Haeckel’s oracular *Welträtsel* (*The Riddle of the Universe*), which repeated his claims about evolution and embryonic development for a mass readership. The public response to *Welträtsel*, whether enthusiastic or hostile, was far less concerned than the scientific community had been with the subtleties involved in assessing the objectivity of scientific pictures. Now the politics were the serious stuff. The integrity of Haeckel’s pictures became a focal point in conflicts over evolution and its uses. In the first decade of the 20th century, an anti-evolutionist ‘scientific thug’ called Arnold Brass vigorously disputed the integrity of Haeckel’s embryo images: he claimed that Haeckel had made them up, adding more vertebrae or taking some away where they were needed to make an evolutionary point; he had distorted other features too, labelling a gibbon embryo as human, and adding an ape’s head and tail to a human embryo. Articles appeared calling Haeckel a ‘forger’ and a ‘disgraceful stain on German science’.

Haeckel considered going to law, decided not to, but then did something even less well advised: he resolved to give his critics and the public a quick philosophical lecture on the nature of scientific representation. In so doing, he greatly overestimated the public’s sophistication and underestimated its attachment to different notions of what scientific pictures should be pictures of. ‘Perhaps 6 or 8 per cent’ of his embryo pictures were ‘forged’ in the sense that his critics meant. But they should understand that it was really quite normal when evidence was incomplete to ‘fill in the gaps with *hypotheses* and to reconstruct the missing links by *comparative synthesis*’. Scientific observation and representation are, as philosophers later came to say, ‘theory-laden’ and that was just the way things were. It is possible, Haeckel said, to err in ‘filling the gaps’, but ‘only the specialist embryologist can judge’ what crosses the line into illegitimacy.

The lecture was a tactical mistake. The Christian right knew instinctively what was scientifically legitimate and what was not. ‘A peculiar science!’ a Berlin conservative paper declared: ‘It demands absolute authority, but employs hypotheses, even in its pictures, and then founds its “exact” conclusions on these trimmed representations.’ ‘It has now been clearly proved against this old man,’ another religious paper announced, ‘that he simply forged plates of pictures ... so that they fitted ... his theory of unbelief, but then of course acted as if the pictures were correct ... He has now been caught.’ Haeckel was a fraud and a forger; evolution was founded on the pictures he forged; the matter was settled.

Haeckel died just after the end of the Great War. The Nazis tried to appropriate aspects of

Haeckel’s work – they were especially fond of his theories about the separate origins of human races – but Haeckel’s association with the political left was awkward; one SS officer recalled that he had been branded ‘a forger and fraudster because he retouched pictures of human embryos in order to prove that man descended from the ape.’ The principal dispute about Haeckel’s embryo images, though, occurred in the Anglophone world: it began to surface around the 1920s, surged again in the 1990s, and is still with us. American high school texts, Hopwood notes, ‘adopted Haeckel’s figures earlier and on a larger scale than their British and German counterparts ... Evolution had a higher profile in the more open [early 20th-century] American system, and the forgery charges, less known, were less attached to pictures which, remarkably, would survive.’ But the rise of Protestant fundamentalism – with its theatrical centrepiece in the Tennessee Scopes trial of 1925 – threw a spanner in the works of American evolutionism, and Haeckel’s embryo pictures became a focus in the emerging battles between evangelical religion and secularism. Writing in 1935, the anti-evolutionist preacher Harry Rimmer was alarmed by the prevalence of Haeckel’s grid in school textbooks and reminded readers that ‘these pictures are all “schematised!”’, their author having been forced to admit that ‘he had “schematised” them to conform to his argument.’

There’s a line – though not a straight one – between these early-century episodes and the disputes over Haeckel’s pictures that broke out in the 1990s. One new element was introduced by academic biologists wholly convinced of the fact of evolution. A group led by the English embryologist Michael Richardson published several scientific papers resuscitating the forgery charges in the course of criticising scientific belief in a ‘highly conserved’ evolutionary stage among vertebrate embryos. Richardson claimed that Haeckel had covered up and massaged evidence of real dissimilarities: this is, Richardson said, ‘turning out to be one of the most famous fakes in biology’. (It’s important to bear in mind that evolution acts on embryos as well as on adult forms, and Haeckel’s dictum that ‘ontogeny recapitulates phylogeny’ is correct only in the sense that there is a *general* early similarity – not ‘identity’ – among the embryos of related species.) Among the minority of American evolutionary biologists dissenting from Darwin’s stress on gradual change, Harvard’s eloquent and influential Stephen Jay Gould, writing in an essay titled ‘*Abscheulich!* (Atrocious)’ in 2000, criticised the continuing presence of Haeckel’s grid in textbooks, aligning himself with Richardson’s accusations. The ‘news’ had already been picked up by *Science* magazine in 1997 – ‘Haeckel’s Embryos: Fraud Rediscovered’ – and given a new lease on life in American culture at a time when a lot of attention was being paid to allegations of mass fraud and misconduct in contemporary science.[*]

But these scientists were blindsided by other actors who were glad of the opportunity to remind people of Haeckel’s ‘fraudulent’ images, notably Young Earth Creationists and their cultural allies in the American Intelligent Design movement. They used the internet to distribute the Good News that evolution rested on a lie and that evolutionary scientists

themselves had uncovered the lie. Creationists appeared on American TV brandishing copies of Haeckel’s embryos and citing the exposés produced by Richardson and others. They quoted Gould on ‘the evocative power of a well-chosen picture’. Images that were intended to provide strong support for the theory of evolution are now circulated by those meaning to oppose it. The pictures remain powerful, but their power is difficult to control.

Pictures can do much and we expect much of them. Sometimes too much. In our Photoshopped world, there is widespread awareness that pictures can be produced with an intention to deceive, but less appreciation of the way in which every picture deceives. All pictures, photographs included, are a hybrid of the things they represent, the conventions used to represent them, the purposes for which the pictures are meant, and the schema used to interpret them. No picture maps directly onto reality. The trek through Hopwood’s dense and scrupulously researched book can be demanding, but there is no more focused account of the subtle and complex relationships between scientific images and what they represent. Were Haeckel’s pictures lies? It depends on what you think Haeckel intended in making them, and it depends on what you mean by a lie.

[*] Steven Shapin wrote about one such episode, the ‘Baltimore case’, in the *LRB* of 4 March 1999.

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