

Haeckel's embryos: fraud not proven

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Through the last half of the nineteenth century and the first part of the twentieth, no scientist more vigorously defended Darwinian theory than the German Ernst Haeckel (1834–1919). More people learned of the new ideas through his voluminous publications, translated into numerous languages, than through any other source, including Darwin's own writings. He enraged many of his contemporaries, especially among the religiously orthodox; and the enmity between evolutionary theory and religious fundamentalism that still burns brightly today may in large measure be attributed to Haeckel's unremitting attacks on the ingressions of religion into science. Though he retained a life-long friendship with and the support of Darwin, some in the scientific community who were critical of evolutionary theory—Emil Du Bois-Reymond, Rudolf Virchow, and Louis Agassiz, for instance—accused him of deception. That charge has been renewed in our time based on seemingly incontrovertible evidence.

In a *Science* magazine article published in 1997, “Haeckel's Embryos: Fraud Rediscovered,” Haeckel, was indicted of having intentionally misrepresented embryological development (Pennisi 1997). The article reported that the work of Michael Richardson and his colleagues demonstrated this malfeasance through a comparison of Haeckel's illustrations of early-stage embryos with photographs of the same species at a comparable stage (see Fig. 1). The photos showed embryos of various species that differed among themselves and certainly from Haeckel's images. The differences were striking and the implication obvious: fraudulent misrepresentation. Richardson, as quoted in the article, affirmed the charge: “It looks like it's turning out to be one of the most famous fakes in biology”

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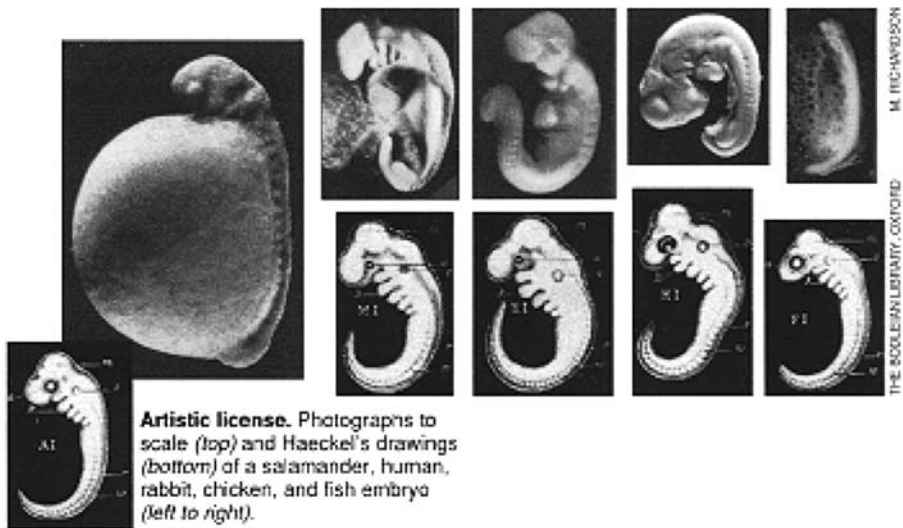


Fig. 1 Illustration from Elizabeth Pennisi, “Haeckel’s Embryos: Fraud Rediscovered,” *Science*, 1997

(Pennisi 1997).¹ The popular press immediately picked up the story, running it under such headlines as: “An Embryonic Liar” (Hawkes 1997). It was not long thereafter that creationists and advocates of intelligent design ignited thousands of websites in an electronic auto-da-fé wherein Haeckel’s reputation and that of Darwinian theory generally were sacrificed to appease an angry God (see the use made of the work of Richardson et al. by the creationist Jonathan Wells in Wells 2000, 2006). It had long been assumed that Haeckel’s racist construction of human evolution had contributed to the work of the Nazis, and now the photographic evidence seemed to confirm his meretricious character. Many reputable biologists quickly accepted the conclusion of the *Science* article, but then sought to distance Haeckel’s version of evolution from that of Darwin. Stephen Jay Gould, for example, thought the indictment justified Louis Agassiz’s judgment of Haeckel: “*Abscheulich!* (Atrocious!)” (Gould 2000). Ever since the appearance of his book *Ontogeny and Phylogeny* (1977), Gould had been trying to distinguish Haeckel’s evolutionary views from Darwin’s—especially concerning the idea that the development of a given embryo morphologically recapitulated the evolutionary history of its phylum. Richardson’s evidence gave dramatic support for Gould’s many efforts to discredit Haeckel (see, e.g., Gould 1977, 1980, 1985, 1989, 2003). The historical and biological evidence, however, shows the charge against Haeckel to be logically mischievous, historically naive, and founded on highly misleading photography.

Science based its report on an article by Richardson et al. (1997) in *Anatomy and Embryology*. They argued that vertebrates did not go through an early

¹ Though Richardson never retracted this judgment, he seems to have moderated his view in a subsequent article (see Richardson and Keuck 2003). The authors write: “Haeckel’s much criticized embryo drawings are important as phylogenetic hypotheses, teaching aids, and evidence for evolution. While some criticisms of the drawings are legitimate, other are more tendentious” (p. 495).

embryological stage (the so called “phylotypic stage”) in which different species were morphologically quite similar, although this had been the conviction of many embryologists of the past and the present. They maintained that not only did Haeckel's images misrepresent the actual state of embryos but so did those of Wilhelm His, perhaps the most famous embryologist of his day and Haeckel's bitter enemy. His, they contended, also exaggerated the similarities of embryos and ignored their differences. The main point of the article by Richardson and his colleagues, however, was to show that embryologists in the late twentieth century did little better. The authors, though, accused no one of fraud. That charge was made in the *Science* article, and then only against Haeckel. Parity of reasoning should logically have required another conclusion: if the indictment of fraud should be made against Haeckel because of too-similar images, then it ought to be brought also against His and the many modern embryologists whom Richardson and his colleagues cited, since they, too, supposed a phylotypic stage in embryogenesis (Richardson et al. cite the following modern embryologists as believing in a phylotypic stage in which vertebrate embryos very closely resemble one another: Butler and Juurlink 1987; Wolpert 1991; Slack et al. 1993; Alberts et al. 1994; Collins 1995). Actually, these recent embryologists ought to have been judged more culpable, given the increase of knowledge, standards, and instrumentation during the last 125 years.

Richardson and his colleagues chose to compare their photographs with images taken from Haeckel's *Anthropogenie: oder, Entwicklungsgeschichte des Menschen* (Anthropogenie: or the developmental history of man) (Haeckel 1874). This was one of Haeckel's popular defenses of evolutionary theory. The book grew out of a series of lectures that he gave to a general audience in 1873; he then quickly reworked them from stenographic notes taken by two of his students. Haeckel's lectures and his volume were replete with many illustrations by his own hand, including the comparative illustration supporting the recapitulation hypothesis (Fig. 2). It was from this latter that Richardson and his colleagues selected images of embryos for comparison.

There are several matters of historical importance that one must keep in mind when judging the veracity of Haeckel's work. First, his lectures were meant for a popular audience, and thus some didactic license would have been permitted. Second, Haeckel was a marine biologist, not a vertebrate biologist, though highly skilled in the latter field. Consequently he borrowed and adapted many of his illustrations, with acknowledgment, from experts in vertebrate biology. From our perspective, these images are a bit crude. If one compares Haeckel's images of embryos at the intermediate stage with those used by Darwin in the *Descent of Man* (Fig. 3), one can appreciate the schematic character of images typical of the time. Indeed, Darwin acknowledged that he borrowed his images from two of the same sources as did Haeckel (Darwin 1871, p. 16). Since Darwin also attempted to drive home the similarities of vertebrate embryos, perhaps not even he should escape condemnation. Third, in the *Science* article, Richardson suggested that Haeckel “fudged the scale” of the embryos, even though there was a tenfold difference in magnitude among them. Haeckel, however, quite explicitly stated in the caption to his illustration that he reduced all of the images to the same size to facilitate

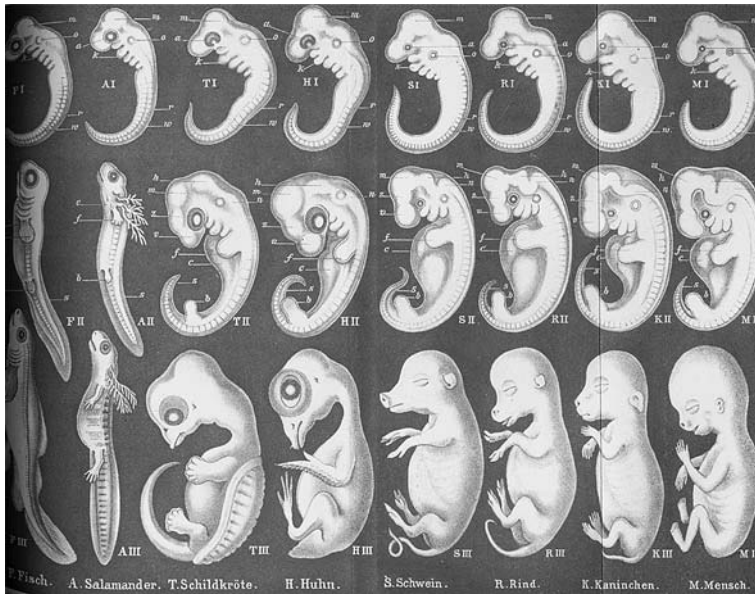


Fig. 2 Illustration from Ernst Haeckel, *Anthropogenie* (1874)

structural comparisons (Haeckel 1874, p. 256). Finally, Richardson and his colleagues selected images from the first edition of Haeckel's *Anthropogenie*, which was hastily drawn together from his lectures. The book, though, went through five further editions. With each new edition the text grew fatter as Haeckel deployed more evidence; and the illustration in question expanded the comparison from 8 species of embryo to 20 by the 5th edition (1905). In the subsequent editions, the images grew ever more refined, so that even by the 4th edition (1891), the differences among them became more pronounced (Fig. 4). The refinements were a function of more material available and better instrumentation (embryos at the earliest stages are invisible to the naked eye). Had the *Science* article compared Richardson's photos with illustrations from Haeckel's later editions, the argument for fraud would have withered.

But what about the considerable disparity between the images in the first edition of Haeckel's book and the photographs by Richardson and his colleagues? Even with the exculpatory logical and historical considerations I have mentioned, how could a biologist of integrity represent a salamander embryo, looking like a lopsided beach ball in the photograph, as a slim, streamlined creature? It is that magnitude of difference that condemns Haeckel. But precisely here is the most dubious aspect of the case against him: several (but not all) of the photographed embryos retain the attached yolk sack and other maternal material; this exaggerates their differences from Haeckel's images (see Fig. 1). Haeckel explicitly indicated that he pictured his specimens without yolk, allantois, and amnion (Haeckel 1874, p. 256). The bulge of the salamander is not part of the embryo; rather, it is the yolk sack, as is the case for the fish and the human embryos (though not for the chick and the rabbit, from which

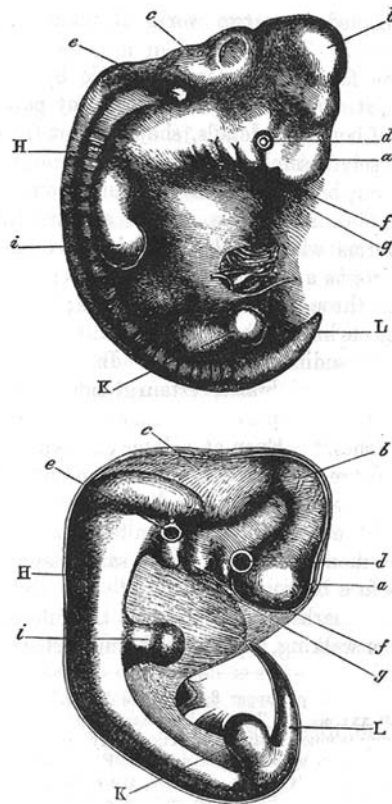


Fig. 1. Upper figure human embryo, from Ecker. Lower figure that of a dog, from Bischoff.

Fig. 3 Illustration showing similarities between human and dog embryo, from Charles Darwin, *Descent of Man* (1871)

the yolk sacks have been removed); moreover the salamander photo is obviously not reduced to the same scale as the others (despite the assertion in the caption for the figure in *Science*). The chick was photographed in a highly circumflex orientation, which occurs at a somewhat later stage of development than that represented by Haeckel. Again, Haeckel expressly stated that he oriented his embryos all in the same way for ease of comparison. I have used a computer program to remove the yolks in the photographs, scale back the salamander, and straighten out the chick (Fig. 5). The result is a bit crude, but one can clearly see that the differences between photograph and illustration are not nearly as great as presented in the *Science* article. Shorn of yolk, the photographed embryos would not have provided the kind of graphic evidence upon which the *Science* article was premised.

Haeckel was a man of great genius and driving passion. At times his impulsive energies led him astray, and he gave his opponents some cause for their complaints.

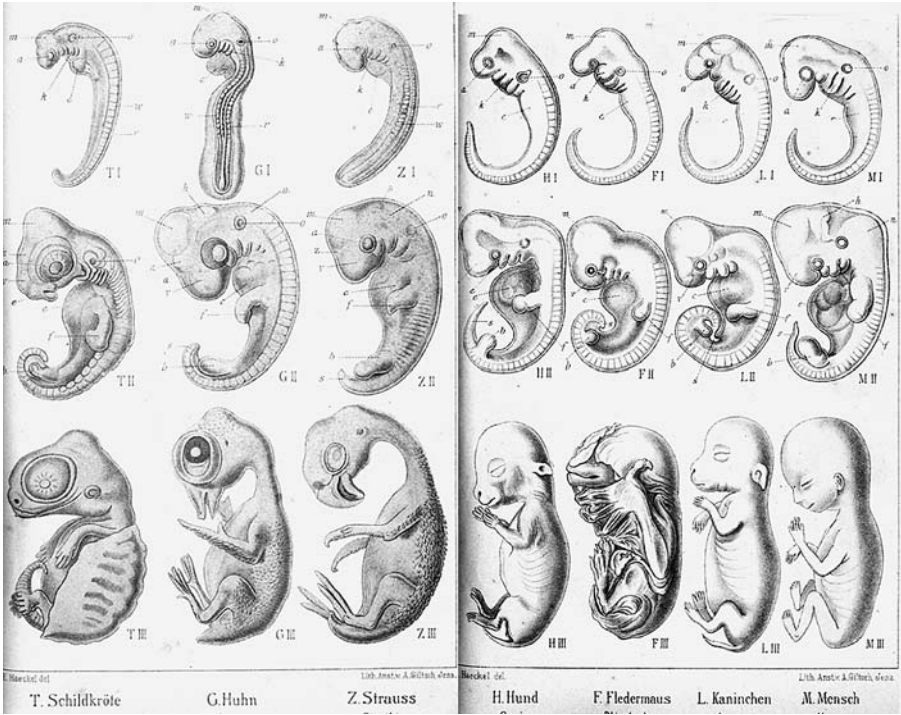


Fig. 4 Illustrations from Ernst Haeckel, *Anthropogenie*, 4th ed. (1891)

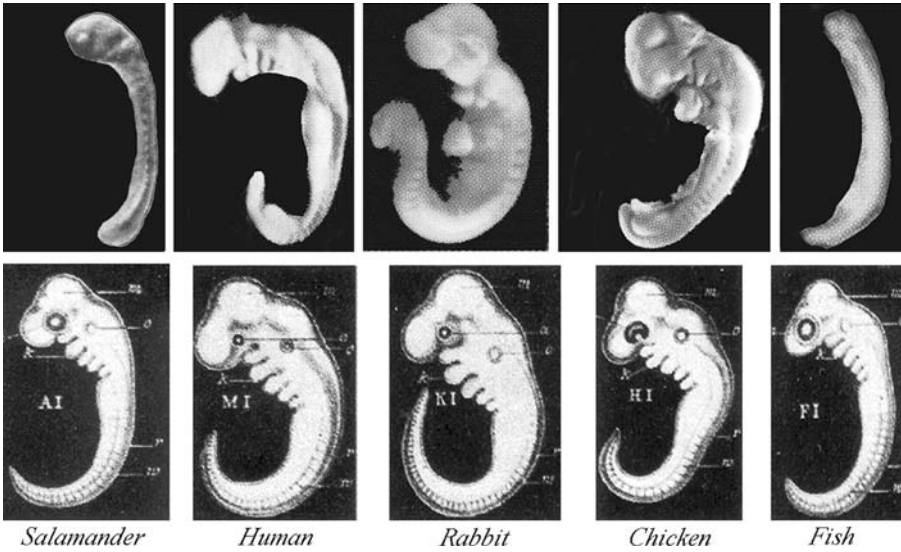


Fig. 5 Reengineered photographs of embryos in Fig. 1 with yolk material removed, comparable scaling, and orientation

In the first edition (1868) of his wildly popular *Natürliche Schöpfungsgeschichte* (Natural history of creation), he used the same wood cut three times to represent the initial formation of embryos of dog, chicken, and turtle. When a reviewer noticed this (Rütimeyer 1868), Haeckel defended himself by arguing you could not tell the differences among these vertebrates at this very early-stage; and given the instrumentation at the time, this was true. He nonetheless recognized that he egregiously erred and immediately corrected the text in the next edition two years later. But the damage was done, and his enemies never ceased to remind readers of his misstep. Even with this stumble, however, he did not lose the support of such stalwarts as Darwin, Thomas Henry Huxley, August Weismann, and Carl Gegenbaur. When Haeckel's science is placed in the wider context of his particular circumstances and the times, as I have attempted to do in my recent intellectual biography, his accomplishments appear in a decidedly more favorable light (Richards 2008). And in the particular instance under reviewed here, I think that light shows that fraud has not been proven.

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References

- Alberts B, Bray D, Lewis J, Raff M, Roberts K, Watson J (1994) *Molecular biology of the cell*, 3rd edn. Garland, New York
- Butler H, Juurlink B (1987) *An atlas for staging mammalian and chick embryos*. CRC Press, Boca Raton
- Collins P (1995) *Embryology and development*. In: Collins P (ed) *Gray's anatomy*, 38th edn. Churchill Livingstone, London, pp 91–341
- Darwin C (1871) *The descent of man and selection in relation to sex*, 2 vols, 1st edn. Murray, London
- Gould SJ (1977) *Ever since Darwin*. Norton, New York, pp 215–217
- Gould SJ (1980) *The Panda's Thumb*. Norton, New York, pp 237–241, 346–347
- Gould SJ (1985) *The Flamingo's smile*. Norton, New York, pp 90, 412–413
- Gould SJ (1989) *Wonderful life*. Norton, New York, pp 263–267
- Gould SJ (2000) *Abscheulich!* (Atrocious!), Haeckel's distortions did not help Darwin. *Nat Hist* 109(2):42–49
- Gould SJ (2003) *The Hedgehog, the Fox and the Magister's Pox*. Harmony Books, New York, pp 157–162
- Haeckel E (1874) *Anthropogenie oder Entwicklungsgeschichte des Menschen*. Engelmann, Leipzig
- Hawkes, N (1997) *An Embryonic Liar* (London) *Times*, p 14
- Pennisi E (1997) Haeckel's embryos: fraud rediscovered. *Science* 277:1435
- Richards RJ (2008) *The tragic sense of life: Ernst Haeckel and the struggle over evolutionary thought*. University of Chicago Press, Chicago
- Richardson M, Keuck G (2003) Haeckel's ABC of evolution and development. *Biol Rev* 77:495–528 (The authors write: Haeckel's much criticized embryo drawings are important as phylogenetic hypotheses, teaching aids, and evidence for evolution. While some criticisms of the drawings are legitimate, other are more tendentious, p 495)
- Richardson M, Hanken J, Gooneratne M, Pieau C, Paynaud A, Selwood L, Wright G (1997) There is no highly conserved embryonic state in the vertebrates: implications for current theories of evolution and development. *Anat Embryol* 196:91–106
- Rütimeyer L (1868) Review of *Natürliche Schöpfungsgeschichte* by Ernst Haeckel. *Arch Anthropol* 3:301–302
- Slack J, Holland P, Graham C (1993) The zootype and the phylotypic stage. *Nature* 361:490–492

Wells J (2000) *Icons of evolution*. Regnery, Washington, DC, pp 81–109

Wells J (2006) *The politically incorrect guide to Darwinism and intelligent design*. Regnery, Washington, DC, pp 27–29

Wolpert L (1991) *The triumph of the embryo*. Oxford University, Oxford