

# Pictures of Evolution and Charges of Fraud

## Ernst Haeckel's Embryological Illustrations

*By Nick Hopwood\**

### ABSTRACT

Comparative illustrations of vertebrate embryos by the leading nineteenth-century Darwinist Ernst Haeckel have been both highly contested and canonical. Though the target of repeated fraud charges since 1868, the pictures were widely reproduced in textbooks through the twentieth century. Concentrating on their first ten years, this essay uses the accusations to shed light on the novelty of Haeckel's visual argumentation and to explore how images come to count as proper representations or illegitimate schematics as they cross between the esoteric and exoteric circles of science. It exploits previously unused manuscripts to reconstruct the drawing, printing, and publishing of the illustrations that attracted the first and most influential attack, compares these procedures to standard practice, and highlights their originality. It then explains why, though Haeckel was soon accused, controversy ignited only seven years later, after he aligned a disciplinary struggle over embryology with a major confrontation between liberal nationalism and Catholicism—and why the contested pictures nevertheless survived.

**N**INETEENTH-CENTURY IMAGES OF EVOLUTION powerfully and controversially shape our view of the world. In 1997 a British developmental biologist accused the

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German zoologist Ernst Haeckel (1834–1919), the leading systematizer and propagandist of Darwinism, of having falsified figures to exaggerate the similarity of vertebrate embryos. Originally published in the first accessible Darwinist system as evidence for common descent, in current textbooks these illustrations still bolstered the view that at a certain stage of development all vertebrates look essentially the same. Creationists leapt on the story, and Haeckel joined the dishonor roll of campaigners against scientific fraud. Yet the charge was old hat; accusations of forgery had already been long and widely debated, most intensely in the 1870s and for a few years before World War I.<sup>1</sup> The latest phase of controversy, sparked by an encounter between taken-for-granted comparative embryological icons and a newly evolutionary developmental biology, is itself rich in interest but has shed more heat than light on the past. Several obstacles stand in the way of deeper engagement: histories of embryology have concentrated on ideas at the expense of picturing practice, while the mixed reputation of Haeckel's biology, the problematic status of his works between popular and academic science, and the difficulty of surveying his archive have discouraged serious study of the evidence. The main problem, however, is the dominant, individualistic understanding of fraud.

A social and historical approach is a precondition of fair judgment and makes it possible to use the charges against Haeckel to illuminate his pictures' novelty and power. Biologists have tended to tackle him as if he were a contemporary, and accuracy by current standards will remain an issue as long as reproductions are in use. But assessments of past fraud should compare suspect actions to the routine science of the day and take account of the negotiations through which malpractice has been defined.<sup>2</sup> Historical claims about visual

<sup>1</sup> On the older controversies see esp. Reinhard Gursch, *Die Illustrationen Ernst Haeckels zur Abstammungs- und Entwicklungsgeschichte: Diskussion im wissenschaftlichen und nichtwissenschaftlichen Schrifttum* (Frankfurt am Main: Lang, 1981). See also Eberhard Dennert, *Die Wahrheit über Ernst Haeckel und seine "Welträtsel": Nach dem Urteil seiner Fachgenossen*, 2nd ed. (Halle: Müller, 1901); Heinrich Schmidt, *Haeckels Embryonenbilder: Dokumente zum Kampf um die Weltanschauung in der Gegenwart* (Frankfurt am Main: Neuer Frankfurter Verlag, 1909); Wilhelm Teudt, "Im Interesse der Wissenschaft!" *Haeckels "Fälschungen" und die 46 Zoologen etc.: Die wichtigsten Dokumente zum Fall Brass-Haeckel nebst Erläuterungen und Ergebnis* (Godesberg: Naturwissenschaftlicher Verlag des Keplerbundes, 1909); J. Assmuth and Ernest R. Hull, *Haeckel's Frauds and Forgeries* (Bombay: Examiner, 1915); Wilbert H. Rusch, Sr., "'Ontogeny Recapitulates Phylogeny,'" *Creation Research Society Annual*, 1969, 6(1):27–34; Britta Rupp-Eisenreich, "Haeckel: La querelle des embryons," in *Dictionnaire du darwinisme et de l'évolution*, ed. Patrick Tort, 3 vols. (Paris: Presses Univ. France, 1996), Vol. 2: F–N, pp. 2090–2114; and Nick Hopwood, "Producing Development: The Anatomy of Human Embryos and the Norms of Wilhelm His," *Bulletin of the History of Medicine*, 2000, 74:29–79. On and in relation to the recent debate see Stephen Jay Gould, "Abscheulich! (Atrocious!): Haeckel's Distortions Did Not Help Darwin," *Natural History*, 2000, no. 3, pp. 42–49; Jonathan Wells, *Icons of Evolution: Science or Myth? Why Much of What We Teach about Evolution Is Wrong* (New York: Regnery, 2000), pp. 81–109, 285–293; Alan D. Gishlick, "Icons of Evolution? Why Much of What Jonathan Wells Writes about Evolution Is Wrong: Icon #4: Haeckel's Embryos," <http://www.ncseweb.org/icons/icon4haeckel.html> (accessed 12 June 2005); Klaus Sander, "Ernst Haeckel's Ontogenetic Recapitulation: Irritation and Incentive from 1866 to Our Time," *Annals of Anatomy*, 2002, 184:523–533; and Michael K. Richardson and Gerhard Keuck, "Haeckel's ABC of Evolution and Development," *Biological Reviews*, 2002, 77:495–528, which gives the revised and extended views of the developmental biologist who started the debate. Richardson's Haeckel appears in Horace Freeland Judson, *The Great Betrayal: Fraud in Science* (Orlando, Fla.: Harcourt, 2004), pp. 82–83.

<sup>2</sup> Jan Sapp, *Where the Truth Lies: Franz Moewus and the Origins of Molecular Biology* (Cambridge: Cambridge Univ. Press, 1990), pp. 1–26; N. J. Mackintosh, ed., *Cyril Burt: Fraud or Framed?* (Oxford: Oxford Univ. Press, 1995); Daniel J. Kevles, *The Baltimore Case: A Trial of Politics, Science, and Character* (New York: Norton, 1998), pp. 107–109; James W. Cook, *The Arts of Deception: Playing with Fraud in the Age of Barnum* (Cambridge, Mass.: Harvard Univ. Press, 2001); Ralph H. Lutts, *The Nature Fakers: Wildlife, Science, and Sentiment* (Charlottesville: Univ. Press Virginia, 2001); and Judson, *Great Betrayal*, pp. 43–98. On forgery in relation to changing representational standards see Jennifer Tucker, "Photography as Witness, Detective, and Impostor: Visual Representation in Victorian Science," in *Victorian Science in Context*, ed. Bernard Lightman (Chicago:

innovation similarly need to recover how producers and users have created pictures with specific meanings. From the mid-nineteenth century, ever-wider circles of readers confronted a host of new representations, many of them joint products of laboratory technologies and industrial communications. Some, such as X-ray photographs, were clearly sensational, but much of the novelty was more subtle. The forgery accusations against Haeckel largely target, not claims to discovery, but figures he was indicted for miscopying from standard academic works into “popular scientific lectures” to illustrate facts he considered long established. Yet though the charges deny him genuine originality, the pictures not only took embryology to fresh audiences; with their characteristic rows for developmental stages and columns for species, their arrangements were new too. They are exceptional, like so much else about Haeckel, but generally significant because they both became canonical and had norms defined against them. The controversies give rare access to innovation where it so often occurs, at the intersection of routine pedagogy, specific disciplinary agendas, and the demands of public appeal.<sup>3</sup>

The debates over Haeckel’s pictures of vertebrate embryos are about what it takes for images to count as proper representations rather than illegitimate schematics as they are trafficked between esoteric and exoteric circles of science. The first illustrations appeared in the *Natürliche Schöpfungsgeschichte* (“Natural History of Creation,” 1868), “perhaps the chief source of the world’s knowledge of Darwinism,” the next in the specifically embryological *Anthropogenie* (1874), which managed six German editions by 1910 and was translated as *The Evolution of Man*. These books are always in danger of being dismissed as either too easy to be original or too difficult to have been widely read, but they were innovative and influential precisely because they took a stand in specialist debates while addressing (and providing journalists with the resources to reach) students and

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Univ. Chicago Press, 1997), pp. 378–408; and Emma Spary, “Forging Nature at the Republican Muséum,” in *The Faces of Nature in Enlightenment Europe*, ed. Lorraine Daston and Gianna Pomata (Berlin: Berliner Wissenschafts-Verlag, 2003), pp. 163–180. Jane M. Oppenheimer, “Haeckel’s Variations on Darwin,” in *Biological Metaphor and Cladistic Classification: An Interdisciplinary Perspective*, ed. Henry M. Hoenigswald and Linda F. Wiener (London: Pinter, 1987), pp. 123–135, on p. 134, criticized Haeckel for not accurately representing the knowledge of her day, and this was Michael Richardson’s starting point too; Rupp-Eisenreich, “Haeckel,” pp. 2106–2107, critiques this approach. Richardson has even argued—implausibly, given the inevitable theory-ladenness of so much drawing—that tendentious copying proves intent to deceive: Michael K. Richardson and Gerhard Keuck, “A Question of Intent: When Is a ‘Schematic’ Illustration a Fraud?” *Nature*, 2001, 410:144. This certainly cannot be shown by comparison with figures produced over thirty years after the event.

<sup>3</sup> For entry points to the literature on science and the visual see Caroline A. Jones and Peter Galison, eds., *Picturing Science, Producing Art* (New York: Routledge, 1998); Alex Soojung-Kim Pang, “Visual Representation and Post-Constructivist History of Science,” *Historical Studies in the Physical and Biological Sciences*, 1997, 28:139–171; Bruno Latour and Peter Weibel, eds., *Iconoclasm: Beyond the Image Wars in Science, Religion, and Art* (Karlsruhe: ZKM; Cambridge, Mass.: MIT Press, 2002); and Soraya de Chadarevian and Nick Hopwood, eds., *Models: The Third Dimension of Science* (Stanford, Calif.: Stanford Univ. Press, 2004). On visual novelties see, e.g., Alberto Cambrosio, Daniel Jacobi, and Peter Keating, “Ehrlich’s ‘Beautiful Pictures’ and the Controversial Beginnings of Immunological Imagery,” *Isis*, 1993, 84:662–699; Lisa Cartwright, *Screening the Body: Tracing Medicine’s Visual Culture* (Minneapolis: Univ. Minnesota Press, 1995); and Thomas Schlich, “Repräsentationen von Krankheitserregern: Wie Robert Koch Bakterien als Krankheitsursache dargestellt hat,” in *Räume des Wissens: Repräsentation, Codierung, Spur*, ed. Hans-Jörg Rheinberger, Michael Hagner, and Bettina Wahrig-Schmidt (Berlin: Akademie-Verlag, 1997), pp. 165–190. Specifically on developmental icons see Martin J. S. Rudwick, *Scenes from Deep Time: Early Pictorial Representations of the Prehistoric World* (Chicago: Univ. Chicago Press, 1992); Stephen Jay Gould, “Ladders and Cones: Constraining Evolution by Canonical Icons,” in *Hidden Histories of Science*, ed. Robert B. Silvers (London: Granta, 1997), pp. 37–67; Hopwood, “Producing Development” (cit. n. 1); Constance Areson Clark, “Evolution for John Doe: Pictures, the Public, and the Scopes Trial Debate,” *Journal of American History*, 2001, 87:1275–1303; and Julia Voss, *Darwins Diagramme: Bilder von der Entdeckung der Unordnung*, Preprint 249 (Berlin: Max-Planck-Institut für Wissenschaftsgeschichte, 2003).

lay readers.<sup>4</sup> The illustrations were so controversial because they were seen as duping people unable to assess them independently. Hostile scientists accused Haeckel of creating false identities by having the eggs and embryos of three different species printed from single blocks. This sharp practice was swiftly corrected and eventually admitted. The critics also alleged that he had used as evidence pictures of objects he had invented and figures that he had tendentiously schematized from well-known originals. This last charge was and is more debatable, and the plates in question have had a long and active life. Opponents highlighted discrepancies; defenders appealed to the pedagogical value of schematics and the theory-ladenness of all effective drawings. Historians have located Haeckel as a Romantic and, more generally, as a late representative of a regime of representation oriented toward truth, in which manipulation was permitted in order to portray types. The leading accuser, the anatomist Wilhelm His, is then seen as working within a new regime of objectivity, committed to self-restraint and the unvarnished depiction of individuals.<sup>5</sup> In using new evidence to assess and extend these interpretations, this essay seeks to go beyond comparing isolated images and commenting on attacks and defenses. It pays close attention to the creation of physical forms and the temporality of viewing as the pictures circulated in different reading communities.<sup>6</sup>

To understand the makers' decisions, I separate the processes of drawing, printing, and publishing the illustrations in the *Schöpfungsgeschichte* and use previously unexploited manuscripts to reconstruct each step. To show how these actions were significant, I place them in relation to routine visual communication in the German university courses where Haeckel learned and taught embryology. This will identify his own contribution to generating the forgery charges and bring out the hitherto unremarked originality of his vivid designs. I then explore how, over the decade from 1868, the figures became controversial in disciplinary struggle and public debate. Reinhard Gursch concluded that trouble came less from the pictures themselves than from the attempts of scientific, philosophical, and ideological opponents to destroy Haeckel's credibility; Jan Sapp suggested, more radically, that the verdict depended on biologists' overall assessment of his achievements.<sup>7</sup> While

<sup>4</sup> Erik Nordenskiöld, *The History of Biology: A Survey*, trans. Leonard Bucknall Eyre (London: Kegan Paul, Trench, Trubner, 1929), p. 515. The only recent English-language biography—Mario A. Di Gregorio, *From Here to Eternity: Ernst Haeckel and Scientific Faith* (Göttingen: Vandenhoeck & Ruprecht, 2005)—all but excludes the *Schöpfungsgeschichte* because it “lacks . . . theoretical significance” (p. 19), while Andreas W. Daum, *Wissenschaftspopularisierung im 19. Jahrhundert: Bürgerliche Kultur, naturwissenschaftliche Bildung und die deutsche Öffentlichkeit, 1848–1914* (Munich: Beck, 1998), p. 307, stresses limits to its popularity. On the making of facts in the traffic between esoteric and exoteric circles see Ludwik Fleck, *Genesis and Development of a Scientific Fact*, trans. Fred Bradley and Thaddeus J. Trenn, ed. Trenn and Robert K. Merton (Chicago: Univ. Chicago Press, 1979), pp. 111–125; and Simon Schaffer, “The Leviathan of Parsonstown: Literary Technology and Scientific Representation,” in *Inscribing Science: Scientific Texts and the Materiality of Communication*, ed. Timothy Lenoir (Stanford, Calif.: Stanford Univ. Press, 1998), pp. 182–222, on p. 221. Fleck cited Haeckel's “biased illustrations appropriate for his theory” as exemplifying “creative fiction,” “the liveliest stage of tenacity in systems of opinion”: *Genesis and Development of a Scientific Fact*, pp. 32, 36.

<sup>5</sup> Lorraine Daston and Peter Galison, “The Image of Objectivity,” *Representations*, 1992, 40:81–128; and Daston, “Objectivity versus Truth,” in *Wissenschaft als kulturelle Praxis 1750–1900*, ed. Hans Erich Bödeker, Peter Hanns Reill, and Jürgen Schlumbohm (Göttingen: Vandenhoeck & Ruprecht, 1999), pp. 17–32, on pp. 28–29. On the main charge of invention see Hopwood, “Producing Development” (cit. n. 1).

<sup>6</sup> For the importance of each step in book production see Robert Darnton, “What Is the History of Books?” in *The Kiss of Lamourette: Reflections in Cultural History* (New York: Norton, 1990), pp. 107–135. On reading see James A. Secord, *Victorian Sensation: The Extraordinary Publication, Reception, and Secret Authorship of Vestiges of the Natural History of Creation* (Chicago: Univ. Chicago Press, 2000); and Jonathan R. Topham, “Scientific Readers: A View from the Industrial Age,” *Isis*, 2004, 95:431–442. On viewing see Anne Secord, “Botany on a Plate: Pleasure and the Power of Pictures in Promoting Early Nineteenth-Century Scientific Knowledge,” *ibid.*, 2002, 93:28–57.

<sup>7</sup> Gursch, *Die Illustrationen Ernst Haeckels zur Abstammungs- und Entwicklungsgeschichte* (cit. n. 1), pp.

such arguments risk denying Haeckel agency—his provocative behavior certainly played a role—they rightly shift attention to his accusers. Indeed, we need to go further, to flesh out our skeletal accounts of Darwinism in Germany by taking more seriously the changing landscape of response.<sup>8</sup> I concentrate on the most influential readers, Haeckel's professorial peers and other reviewers in the scientific and literary press. In this way we can understand the little-noticed fact that for seven years the charges failed to take off—and why the situation changed with the reception of the *Anthropogenie*. This book pushed scientist enemies to attack more publicly and, by aligning embryology's most important disciplinary battle with the major state campaign against the Catholic Church, encouraged other opponents to exploit these criticisms—but Haeckel still did not have to remove most of the contested figures. The key question is not, "Was he a forger?" but, rather, how fraud was made the issue and how the pictures nevertheless survived to become some of the most widely seen embryological illustrations of all time.

#### DRAWING TYPES

The *Natürliche Schöpfungsgeschichte* was illustrated in its first edition with ten lithographed plates—a frontispiece showing heads of human races and apes, a double-page spread of embryos in the middle, and eight evolutionary trees at the back—and only fourteen, mostly embryological, wood engravings in 568 octavo pages. These figures began as drawings, some of which, with crucial early testimony from Haeckel, turn out to have survived in his archive. He learned to draw as a child but was trained to picture embryos in the courses where drawing was central to teaching their complex forms. To reconstruct how he drew for the *Schöpfungsgeschichte*, we need to review the state of embryological pedagogy as he went to work in 1868 and how, to serve the aims of the book, he would transform the available representations.<sup>9</sup>

In the decades around 1800, embryology joined comparative anatomy as a pillar of morphology, the new science of organic form. When anatomy was at a loss to interpret

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137–138; and, with reference to the 1908–1910 controversy only, Sapp, *Where the Truth Lies* (cit. n. 2), pp. 16–22. Embryological representations are surveyed in Nick Hopwood, "Visual Standards and Disciplinary Change: Normal Plates, Tables, and Stages in Embryology," *History of Science*, 2005, 43:239–303, on pp. 245–253. On the courses see Hopwood, *Embryos in Wax: Models from the Ziegler Studio, with a Reprint of "Embryological Wax Models" by Friedrich Ziegler* (Cambridge: Whipple Museum of the History of Science; Bern: Institute of the History of Medicine, 2002), pp. 33–39; and Hopwood, "Plastic Publishing in Embryology," in *Models*, ed. de Chadarevian and Hopwood (cit. n. 3), pp. 170–206, on pp. 182–186.

<sup>8</sup> Alfred Kelly, *The Descent of Darwin: The Popularization of Darwinism in Germany, 1860–1914* (Chapel Hill: Univ. North Carolina Press, 1981); Kurt Bayertz, "Darwinismus als Politik: Zur Genese des Sozialdarwinismus in Deutschland 1860–1900," in *Welträtsel und Lebenswunder: Ernst Haeckel—Werk, Wirkung und Folgen*, ed. Erna Aeschel et al. (Linz: Oberösterreichisches Landesmuseum, 1998), pp. 229–288; and Daum, *Wissenschaftspopularisierung im 19. Jahrhundert* (cit. n. 4).

<sup>9</sup> On drawing in the German lands see Wolfgang Kemp, ". . . einen wahrhaft bildenden Zeichenunterricht überall einzuführen": *Zeichnen und Zeichenunterricht der Laien 1500–1870: Ein Handbuch* (Frankfurt am Main: Syndikat, 1979); Clive Ashwin, *Drawing and Education in German-Speaking Europe, 1800–1900* (Ann Arbor, Mich.: UMI Research Press, 1981); and Elke Schulze, *Nulla dies sine linea: Universitärer Zeichenunterricht: Eine problemgeschichtliche Studie* (Stuttgart: Steiner, 2004), esp. pp. 105–125. It would be worth exploring the relations between the varieties of lay drawing and the techniques Haeckel, his teachers, and his opponents employed as scientists. On his very important and underused archive see Erika Krauß and Uwe Hoßfeld, "Das Ernst-Haeckel-Haus in Jena: Von der privaten Stiftung zum Universitätsinstitut (1912–1979)," in *Repräsentationsformen in den biologischen Wissenschaften: Beiträge zur 5. Jahrestagung der DGGTB in Wien 1996 und zur 7. Jahrestagung in Neuburg a. d. Donau 1998*, ed. Armin Geus et al. (Verhandlungen zur Geschichte und Theorie der Biologie, 3) (Berlin: Verlag für Wissenschaft und Bildung, 1999), pp. 203–232; for a register of 39,220 letters see Hoßfeld and Olaf Breidbach, *Haeckel-Korrespondenz: Übersicht über den Briefbestand des Ernst-Haeckel-Archivs* (Berlin: Verlag für Wissenschaft und Bildung, 2005).



complex adult structures, studying development could show how they arose from simple beginnings. Embryology went on primarily in the German institutes of anatomy and physiology until, from the late 1840s, physiologists oriented toward physics rejected morphology as failing to seek properly causal explanations and claimed separate chairs. Embryology remained in anatomy and gained the new institutes of zoology as its other main home. Anatomists introduced special courses in human embryology that by midcentury were becoming small but standard parts of the medical curriculum.<sup>10</sup>

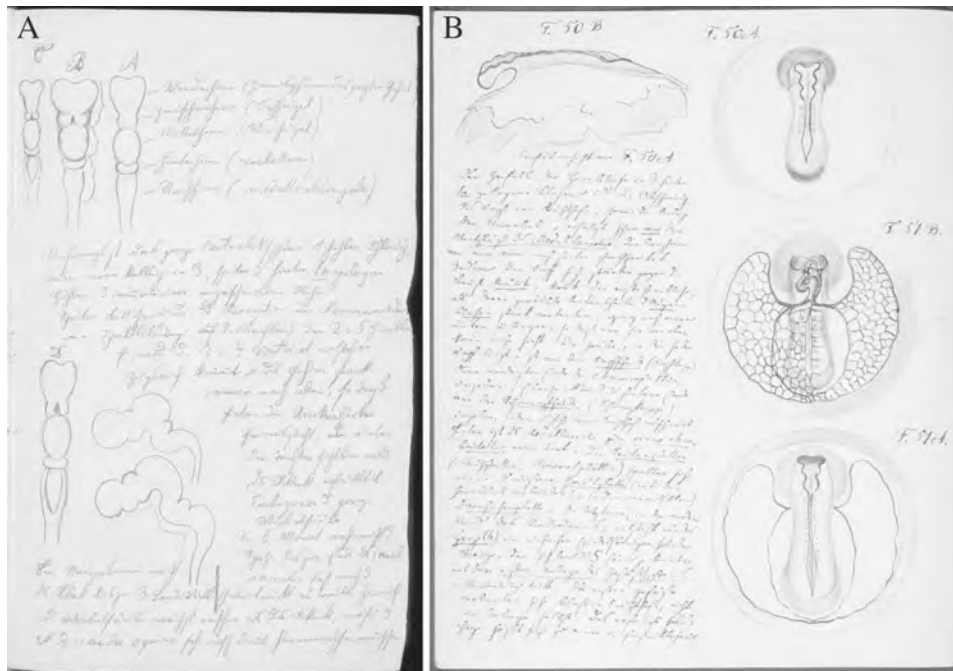
Embryology organized its objects by making developmental series. Specimens, often difficult to obtain at desired stages, were collected and framed as embryos; some had previously been interpreted in very different terms—for example, as children to come or as waste material. The tiny and initially unprepossessing objects were transformed through sequences of anatomical, microscopical, and artistic operations into clear images, of which the most expensive conveyed some of the soft, translucent delicacy of the living material. These procedures isolated embryos from other contexts, including connections to pregnant women. The resulting pictures and models were arranged in developmental order, normal representatives selected, and the series prepared for publication or display. This was far from trivial even for the chick, the workhorse of embryological research; for the early human embryos that anatomists mostly obtained from abortions (the youngest then known were estimated at about two weeks old) it was extremely hard. Working out the relations between the series for different species was even harder. Did human embryos recapitulate the forms of all the major groups of adult animals, as many Romantics argued, or was the animal kingdom, as the influential Karl Ernst von Baer would have it, instead divided into four separate types, within which development did not run in parallel but diverged? It was, however, agreed that all vertebrates develop within a common ideal type.<sup>11</sup>

By midcentury lecturers generally were using more and more visual aids, but embryology was considered to depend on illustration to an unusual degree because its objects were tiny and complex, as well as unfamiliar. Together with wax models, drawings and drawing were supposed to teach students to see.<sup>12</sup> Most of Haeckel's contemporaries still disliked embryology lectures, but as a student in Würzburg in the 1850s he attended twice. We have his simple sketches from the blackboard and the more elaborate versions from which by 1868 he had taught for several years (Figure 1, A–B), but not the wall charts

<sup>10</sup> For reviews see Frederick B. Churchill, "The Rise of Classical Descriptive Embryology," in *A Conceptual History of Modern Embryology*, ed. Scott F. Gilbert (Baltimore: Johns Hopkins Univ. Press, 1994), pp. 1–29; and Hopwood, "Visual Standards and Disciplinary Change" (cit. n. 7), pp. 241–248.

<sup>11</sup> Hopwood, "Producing Development" (cit. n. 1); Nick Hopwood, "Embryonen 'auf dem Altar der Wissenschaft zu opfern': Entwicklungsreihen im späten neunzehnten Jahrhundert," in *Geschichte des Ungeborenen: Zur Erfahrungs- und Wissenschaftsgeschichte der Schwangerschaft, 17.–20. Jahrhundert*, ed. Barbara Duden, Jürgen Schlumbohm, and Patrice Veit (Göttingen: Vandenhoeck & Ruprecht, 2002), pp. 237–272; and Hopwood, "Visual Standards and Disciplinary Change."

<sup>12</sup> On the visual aids see Hopwood, *Embryos in Wax* (cit. n. 7), esp. pp. 33–39; on microscopical discipline see L. S. Jacyna, "'A Host of Experienced Microscopists': The Establishment of Histology in Nineteenth-Century Edinburgh," *Bull. Hist. Med.*, 2001, 75:225–253. For Haeckel's enthusiastic attendance at embryology lectures see Haeckel to his parents, 14 May 1853, 17 May 1855, in Ernst Haeckel, *Entwicklungsgeschichte einer Jugend: Briefe an die Eltern 1852/1856*, ed. Heinrich Schmidt (Leipzig: Koehler, 1921), pp. 53, 137; and Georg Uschmann, "Über die Beziehungen zwischen Albert Koelliker und Ernst Haeckel," *NTM*, 1974, 11:80–89, on p. 82. For other students' difficulty and his own lectures see Haeckel, *Anthropogenie oder Entwicklungsgeschichte des Menschen: Gemeinverständliche wissenschaftliche Vorträge über die Grundzüge der menschlichen Keimes- und Stammes-Geschichte* (Leipzig: Engelmann, 1874), p. xv; and, further on his lectures, Uschmann, *Geschichte der Zoologie und der zoologischen Anstalten in Jena 1779–1919* (Jena: Fischer, 1959), p. 46. The notes from which a page is reproduced in Figure 1, A support Uschmann's assumption that Kölliker lectured Haeckel on embryology in 1853 as well as 1855, but the 1853 letter refers to a course by Franz Leydig.

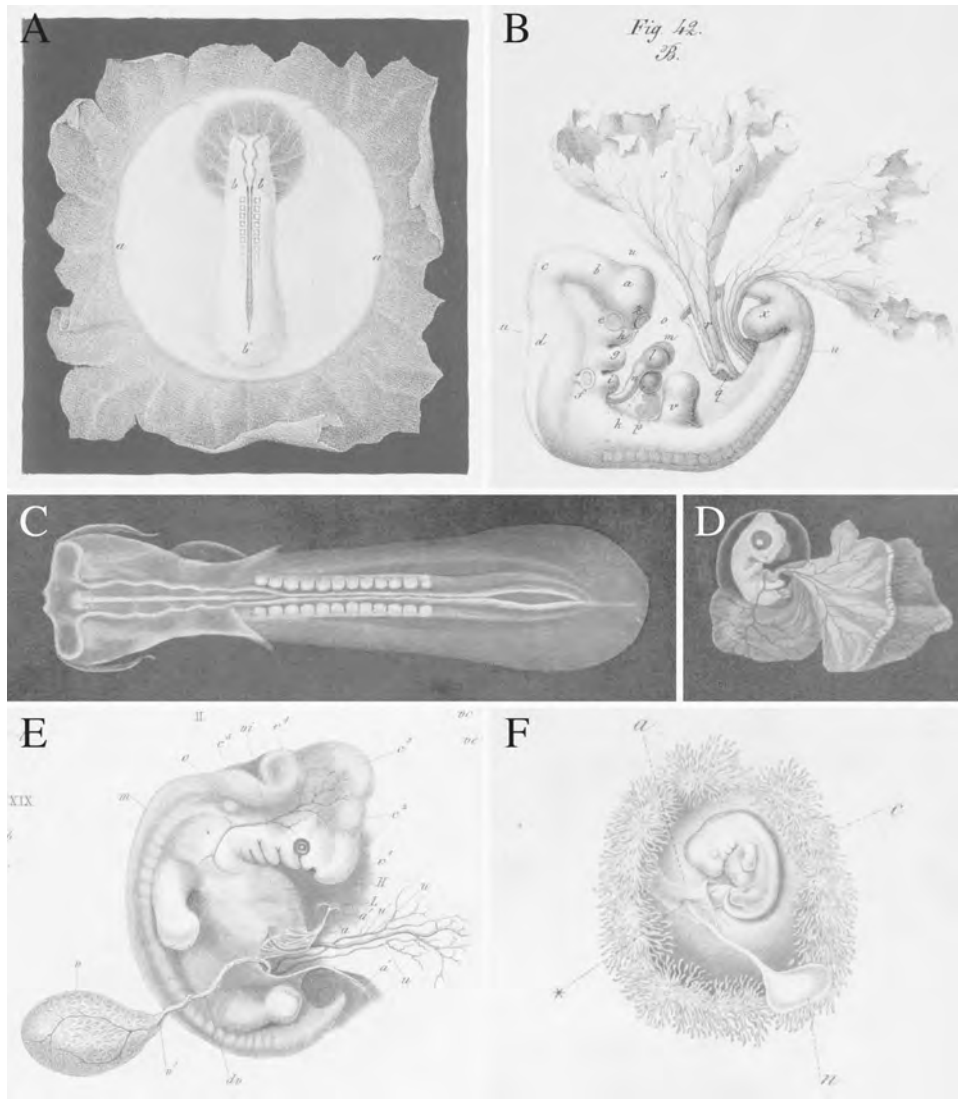


**Figure 1.** Haeckel's classroom drawings. (A) Pencil sketches of human brain development made during an embryology lecture. From a notebook, "Kölliker: Embryologie: Würzburg 1853." (B) Drawings in black pen and blue and orange crayons in the notes from which Haeckel taught "Human Embryology," here specifically the overall organization of the mammalian embryo, including ("F. 51B") the formation of the heart and embryonic circulation. From "Embryologie des Menschen: Dr Haeckel: Jena: Sommer-Semester 1863." Ernst-Haeckel-Haus, Jena: (A) B286, (B) B102.

that in some institutes already enlarged illustrations too complex to do on the spot. These informal, local drawings generally derived from anatomists' authoritative and widely distributed printed figures. Research monographs, such as Theodor Bischoff's standard studies of early mammalian development (Figure 2, A–B; see also cover illustration), provided pictures that students mostly saw as reproductions. When Haeckel studied embryology, barely illustrated textbooks were supplemented by large-format plates, notably those authored by Alexander Ecker (Figure 2, E–F); Michael Erdl's were big enough to see in class (Figure 2, C–D). Like Bischoff's figures of rabbit development (Figure 2, A), these are reversed, white on black, to mimic the effect of reflected-light microscopy; the delicate, translucent structures stand out while allowing fine modeling within the outline. By the time Haeckel was lecturing, he could use his teacher Albert Kölliker's textbook, with its wealth of fine wood engravings (Figure 3, A–B).<sup>13</sup>

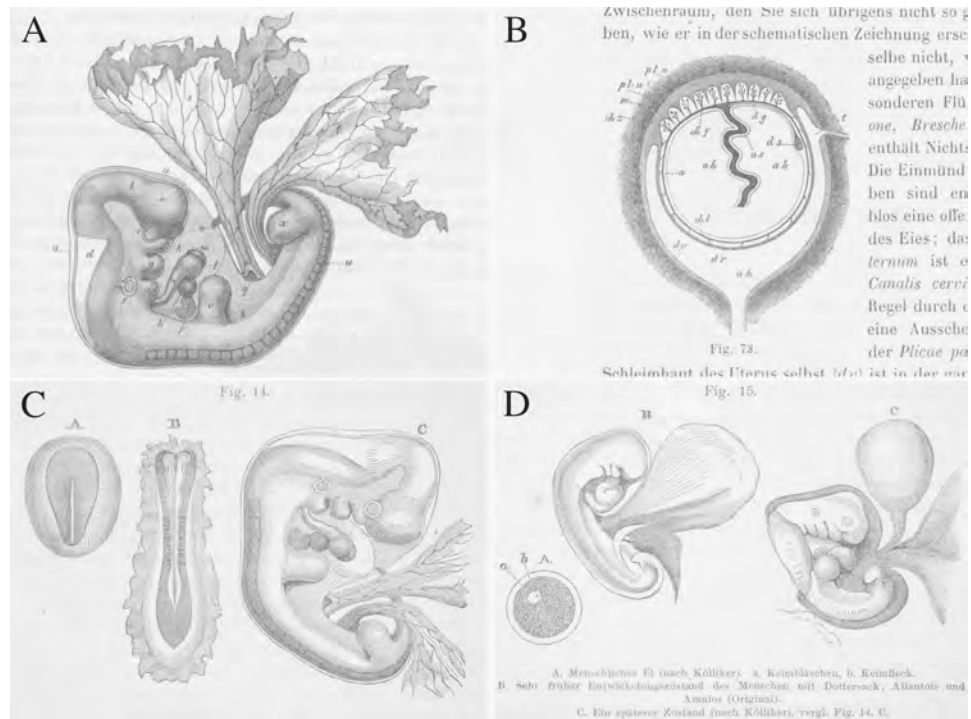
These drawings were not primarily directed toward comparison; those in Figure 2 first appeared on plates with other specimens of the same species only. Branching diagrams

<sup>13</sup> None of these standard atlases and textbooks traditionally figures in histories of embryology. On wall charts, especially those that were later produced commercially, see Massimiano Bucchi, "Images of Science in the Classroom: Wallcharts and Science Education, 1850–1920," *British Journal for the History of Science*, 1998, 31:161–184; and Carlo Alberto Redi et al., *Visual Zoology: The Pavia Collection of Leuckart's Zoological Wall Charts (1877)* (Como: Ibis, 2002). The embryological charts that survive in the Jena Zoological Institute, including some from Haeckel's time, appear more recent than the 1860s.



**Figure 2.** High-quality pictures from monographs and atlases of the 1840s and 1850s that served Haeckel as partial models for his drawings of vertebrate embryos. (A–B) Lithographs of (A) a ten-somite rabbit embryo from the anatomist Theodor Bischoff’s prize-winning embryology of the rabbit, and (B) a twenty-five-day dog embryo from his history of dog development. (C–D) Steel engravings of (C) a thirty-three-hour and (D) a seven-day chick embryo from an atlas Haeckel admired by the Munich anatomist Michael Erdl, who unusually engraved his own work. (E–F) Copper engravings of human embryos in the Freiburg anatomist Alexander Ecker’s standard atlas: (E) no age given, but about four weeks; (F) five weeks. (A–B) Lithographs by A. Schütter of Bonn after Bischoff’s drawings, printed by Henry & Cohen of Bonn, from (A) *Entwicklungsgeschichte des Kaninchen-Eies* (Braunschweig: Vieweg, 1842), figure 57 on Plate XIII (original figure 8.2 cm high), and (B) *Entwicklungsgeschichte des Hunde-Eies* (Braunschweig: Vieweg, 1845), figure 42B on Plate XI (7.0 cm high), by permission of the Syndics of Cambridge University Library; (C–D) from M. P. Erdl, *Die Entwicklung des Menschen und des Hühnchens im Eie, Vol. 1: Entwicklung der Leibesform* (Leipzig: Voss, 1845), (C) Plate VIII, figure 2 (15.3 cm high, here rotated 90 degrees to the left), and (D) Plate III, figure 3 (4.1 cm high), Whipple Library, Cambridge; (E–F) engravings by C. E. Weber of Berlin after drawings by J. Lerch in Alexander Ecker, *Icones physiologicae* (Leipzig: Voss, 1851–1859), (E) Plate XXX, figure ii (5.8 cm greatest embryo length), and (F) Plate XXVI, figure viii (1.1 cm greatest embryo length), Balfour Library, Cambridge.





**Figure 3.** Wood engravings of dog and human embryos from the early 1860s. From Albert Kölliker's standard textbook, (A) a dog embryo after Theodor Bischoff (Figure 2, B in this article), and (B) the "egg membranes of man in situ, represented schematically." From T. H. Huxley's evolutionary essays, (C) dog development, from the "earliest rudiment" to the "very young puppy," unattributed but clearly indebted to Bischoff, and (D) human development, from the ovum through a "very early condition" to a "more advanced stage," the first and last said to be "after Kölliker," the middle one "original." Huxley refers to the "marvellous correspondence" "apparent by the simple comparison of the figures." (A–B) Engravings by Johann Gottfried Flegel after drawings by Karl Lochow, from Albert Kölliker, *Entwicklungsgeschichte des Menschen und der höheren Thiere* (Leipzig: Engelmann, 1861), figure 60 on page 117 (7.1 cm high) and figure 73 on page 138, Whipple Library, Cambridge; (C–D) from T. H. Huxley, *Zeugnisse für die Stellung des Menschen in der Natur* (Braunschweig: Vieweg, 1863), figure 14 on page 65 (figure 14C 4.8 cm wide) and figure 15 on page 68, Bayerische Staatsbibliothek, Munich.

occasionally showed the relations of animal development, but the best-known comparative images were cross-sections of the vertebrate type. The few plates that present whole embryos of more than one species tend to depict the different animals in different views and at different sizes and so do not make comparison easy. The most famous comparative studies dealt with particular organ systems rather than whole embryos, and surveys such as Kölliker's used chick and domestic mammalian embryos to produce a coherent account that could stand for human development, the chief medical concern. Nor were embryological illustrations very vivid. Though important as the analogy that underwrote much transformism, embryology belonged in medical institutions, sex-advice books, and popular anatomy museums. It was not taught at school and not really polite, and it is not generally as prominent in the German popular-science writing that took off following 1848 as it is in the familiar letters of the materialist zoologist and embryologist Carl Vogt. Even Thomas Henry Huxley's evolutionary essays of 1863, with the "inspired visual propaganda" of

their frontispiece showing ape and human skeletons marching in step, offered little advance; human and dog series appeared on different pages (Figure 3, C–D). Specialists could always draw their own comparisons, but Haeckel, seeking to make comparative embryology central to a Darwinist worldview, had to engage people who could not.<sup>14</sup>

Haeckel aimed to reform morphology and place it at the heart of German culture. Promoted on the strength of an impressive study of the radiolaria to a new professorship of zoology at the University of Jena, he joined the comparative anatomist Carl Gegenbaur in a project to defend morphology against the physicalist physiology of Carl Ludwig, Hermann Helmholtz, Emil du Bois-Reymond, and Ernst Brücke. The Jena partnership used Darwin's theory to turn ideal archetypes into physical ancestors without fundamentally changing the goals and structure of the science. Haeckel's 1866 *Generelle Morphologie* raised Lamarck and Goethe into the pantheon along with Darwin. Haeckel was as determined as the Prussian chancellor Otto von Bismarck, in the wars then unifying Germany, to capture as much ground as possible by daring and rapid attack. So this first Darwinist system pushed way beyond the facts to detailed evolutionary trees, including for human beings. In the absence of fossils, Haeckel relied on embryos as evidence of ancestors. An evolutionized doctrine of recapitulation taught that individual development, which he here called "ontogeny," rapidly and concisely repeats "phylogeny," the evolutionary development of the species. Reacting against post-Romantic empiricism and the fragmentation of the sciences, he wrote in the tradition inspired by Alexander von Humboldt's *Kosmos*. Haeckel's unusually combative, polarizing denunciation of tradition, superstition, and prejudice created a revolutionary impression, while drawing on attitudes common in the educated Protestant middle class. A liberal "monism" tamed Vogt's materialism. Evolution was the organizing principle of a cosmic synthesis that would unify science, religion, and art on a biological foundation.<sup>15</sup>

<sup>14</sup> On branching diagrams see Voss, *Darwins Diagramme* (cit. n. 3); for the dearth of comparative images in earlier embryology see Hopwood, "Visual Standards and Disciplinary Change" (cit. n. 7), pp. 247–248. Among the most striking is Rudolph Wagner, *Icones physiologicae: Tabulae physiologiam et geneos historiam illustrantes: Erläuterungstafeln zur Physiologie und Entwicklungsgeschichte* (Leipzig: Voss, 1839), Plate V. Schematics of the embryonic membranes of human and dog are on the same page in Carl Vogt, *Zoologische Briefe: Naturgeschichte der lebenden und untergegangenen Thiere, für Lehrer, höhere Schulen und Gebildete aller Stände*, 2 vols. (Frankfurt am Main: Literarische Anstalt, 1851), Vol. 1, pp. 422, 546. Chick development is pictured in Lorenz Oken, "Einleitung" to *Abbildungen zu Oken's Naturgeschichte für alle Stände* (Stuttgart: Hoffmann, 1843), pp. 1–3. Vogt, *Physiologische Briefe für Gebildete aller Stände*, 2nd ed. (Giessen: Ricker, 1854), p. 436, decided to discuss reproduction as part of the physiology of generation and development in view of the success of advice books "in duodecimo or even smaller format," on which see Janet Farrell Brodie, *Contraception and Abortion in Nineteenth-Century America* (Ithaca, N.Y.: Cornell Univ. Press, 1994), pp. 87–203. On Huxley's frontispiece see Janet Browne, *Charles Darwin: A Biography*, Vol. 2: *The Power of Place* (London: Pimlico, 2003), p. 221. For the distinction between those who could and could not make their own figures see Ludwig Rüttimeyer, rev. of Haeckel, *Ueber die Entstehung und den Stammbaum des Menschenschlechts und Natürliche Schöpfungsgeschichte*, *Archiv für Anthropologie*, 1868, 3:301–302.

<sup>15</sup> On Haeckel see, most recently, Di Gregorio, *From Here to Eternity* (cit. n. 4), especially on relations with Gegenbaur; Bernhard Kleeberg, *Theophysis: Ernst Haeckels Philosophie des Naturganzen* (Cologne: Böhlau, 2005); and Robert J. Richards, "If This Be Heresy: Haeckel's Conversion to Darwinism," in *Darwinian Heresies*, ed. Abigail Lustig, Richards, and Michael Ruse (Cambridge: Cambridge Univ. Press, 2004), pp. 101–130. For a variety of other perspectives see Daniel Gasman, *The Scientific Origins of National Socialism: Social Darwinism in Ernst Haeckel and the German Monist League* (London: Macdonald; New York: American Elsevier, 1971); Stephen Jay Gould, *Ontogeny and Phylogeny* (Cambridge, Mass.: Harvard Univ. Press, Belknap, 1977); Erika Krauß, *Ernst Haeckel* (Leipzig: Teubner, 1984); Paul Weindling, "Ernst Haeckel, Darwinismus, and the Secularization of Nature," in *History, Humanity, and Evolution: Essays for John C. Greene*, ed. James R. Moore (Cambridge: Cambridge Univ. Press, 1989), pp. 311–327; Lynn K. Nyhart, *Biology Takes Form: Animal Morphology and the German Universities, 1800–1900* (Chicago: Univ. Chicago Press, 1995), pp. 143–206; and Aeschel et al., eds., *Welträtsel und Lebenswunder* (cit. n. 8). On Bismarck see Haeckel to T. H. Huxley, 12 May

The *Generelle Morphologie* could hardly launch such an ambitious program. Though Haeckel rejected accusations of speculation, he acknowledged the formal weaknesses of two long, digressive volumes that mixed polemic with dozens of new technical terms (“ecology” also caught on). They sold poorly, and the distinguished liberal publisher, Georg Reimer of Berlin, resisted a plea for a “*strictly scholarly and objective*” second edition even though his son Ernst was Haeckel’s brother-in-law. Instead, Haeckel turned his successful lectures to students and townspeople in Jena into the *Natürliche Schöpfungsgeschichte*, a comprehensive gospel of evolution that, eclipsing other Darwinist volumes, would more than compensate the Reimers for their earlier loss.<sup>16</sup> Haeckel brought an unusual level of academic authority into the established genre of natural histories of creation. He called his “lectures” “popular” (*gemeinverständlich*) and “scientific” (*wissenschaftlich*), a combination pioneered in a series cofounded in 1866 by his teacher, the left-liberal pathologist Rudolf Virchow, in part to encourage specialists to compete with professional popularizers. Haeckel championed a theory that many of his colleagues had yet to recognize, let alone bless for general consumption, but that he granted educated laypeople the right and ability to grasp, though not to challenge.<sup>17</sup>

Haeckel worked up the text from a student transcript and drew the figures in spring 1868. Three pairs of drawings in the Ernst-Haeckel-Haus in Jena, reproduced for the first time in Figure 4, show dog and human embryos from the fourth week and then, all at roughly the same later stage, dog, human, turtle, and chick embryos. These are surely the drawings for the embryo plate in the first edition. The forms are, in all contested respects, the same as those in the lithograph, and the original numbers are on the back.<sup>18</sup> Since Haeckel never credited or blamed an artist for this work, the labels are in his hand, and he did sign similar plates in the *Anthropogenie*, we may assume that he drew them himself. Aiming for an effect similar to Bischoff’s and Erdl’s (Figure 2, A and C–D), he surrounded the first of each pair with a dark wash to show how all should be printed in white on black; the second drawings give the lettering.

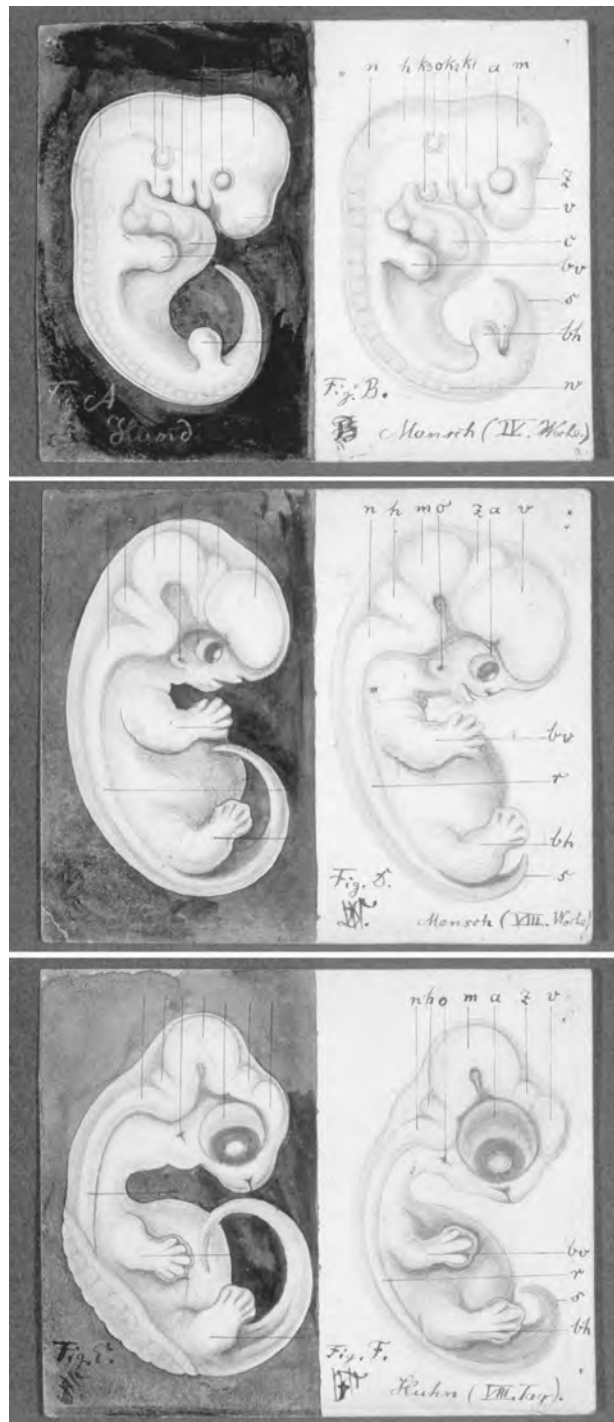
Haeckel did not cite sources, which, though not unusual when addressing a general audience, left his opponents a free hand to make assumptions that he never publicly contradicted head-on. Above all, they would accuse him of tendentiously copying the four-week dog and human embryos from Bischoff and Ecker, respectively (Figure 2, B and E),

1867, in Georg Uschmann and Ilse Jahn, eds., “Der Briefwechsel zwischen Thomas Henry Huxley und Ernst Haeckel: Ein Beitrag zum Darwin-Jahr,” *Wissenschaftliche Zeitschrift der Friedrich-Schiller-Universität Jena, Mathematisch-Naturwissenschaftliche Reihe*, 1959/1960, 9:7–33, on p. 12. On Vogt’s relations to Haeckel see Christoph Kockerbeck, ed., *Carl Vogt, Jacob Moleschott, Ludwig Büchner, Ernst Haeckel: Briefwechsel* (Munich: Basilisken-Verlag, 1999).

<sup>16</sup> Haeckel to Georg Reimer, 18 Sept. 1868, 17 Jan. 1869 (quotation), Staatsbibliothek zu Berlin—Preussischer Kulturbesitz: Dep. 42 (Archiv Walter de Gruyter), R1: Haeckel, Ernst (hereafter cited as **SBB**); and G. Reimer to Haeckel, 21 Jan. 1869, Ernst-Haeckel-Haus, Jena (hereafter cited as **EHH**). On the Reimers see S.W., “Deutsche Buchhändler, 5: Georg Reimer,” *Illustrierte Zeitung*, 1867, 49:223–226; and Rudolf Virchow, “Nachruf an Ernst Reimer,” *Archiv für Pathologische Anatomie und Physiologie und für Klinische Medizin*, 1897, 150:388–390. On the book trade see Reinhard Wittmann, *Geschichte des deutschen Buchhandels: Ein Überblick*, 2nd ed. (Munich: Beck, 1999). On the lectures see Uschmann, *Geschichte der Zoologie* (cit. n. 12), pp. 43–45.

<sup>17</sup> Ernst Haeckel, *Natürliche Schöpfungsgeschichte: Gemeinverständliche wissenschaftliche Vorträge über die Entwicklungslehre im Allgemeinen und diejenige von Darwin, Goethe und Lamarck im Besonderen, über die Anwendung derselben auf den Ursprung des Menschen und andere damit zusammenhängende Grundfragen der Naturwissenschaft* (Berlin: Reimer, 1868), pp. iii–v. On the *Sammlung gemeinverständlicher wissenschaftlicher Vorträge*, edited by Rudolf Virchow and Franz von Holtzendorff, see Constantin Goschler, *Rudolf Virchow: Mediziner—Anthropologe—Politiker* (Cologne: Böhlau, 2002), pp. 202–203; the “Prospekt” on the inside wrappers of the first few issues in this series gives the aims. On Haeckel’s relations to pre-Darwinian transformism see Kleeberg, *Theophysis* (cit. n. 15), pp. 67–79.

<sup>18</sup> These numbers are on Haeckel’s diagram in Figure 6.



**Figure 4.** Drawings presumed to be Haeckel's originals for the embryological plate in the first edition of his *Natürliche Schöpfungsgeschichte* (Berlin: Reimer, 1868). (A–B) Dog and human embryos from the fourth week; (C–D) six-week dog and eight-week human embryos; (E–F) six-week turtle and eight-day chick embryos. Pencil and ink on card, each pair ca. 8 × 10 cm. In folded paper labeled "Nat. Schöpfungsg. Tafel II u. III" in file "Natürl. Schöpfungsgeschichte," Ernst-Haeckel-Haus, Jena: B74.



expanding the dog's head while reducing that of the human embryo, moving its eye forward and enlarging the tail.<sup>19</sup> The dog embryo must have come, directly or indirectly, from Bischoff; but, in place of the human embryo chosen by the first accusers, it has recently been proposed that Haeckel could have copied another of Ecker's illustrations rather faithfully (Figure 2, *F*). Though plausible, this assumes (with Haeckel's critics and at least some friends) that each figure should have a single original. Yet the earliest and most detailed account of his procedure reveals that he did not draw in this way. Writing a few months after publication to a sympathetic colleague who had asked what figures he had copied, Haeckel explained that the forms of the human and dog embryos "are completely exact, partly copied from nature, partly assembled from all illustrations of these early stages that have hitherto become known." He synthesized his views of specimens in Jena and published pictures in order to represent types.<sup>20</sup>

From the eighteenth to the mid-nineteenth century all naturalists drew types, but in various ways. In the late eighteenth century two mainstream traditions had been fairly distinct: "idealizing" anatomists insisted that experience work on particulars to produce perfection, while others employed "naturalistic" illustrators to paint every vein and hair in an effort to make individual specimens characteristic. Haeckel's synthesis recalls Goethe's much more ambitious intuition of the "original plant" from accumulated observations, and Haeckel, who with a bit more talent might have become an artist, was as strongly committed to aesthetic judgment in science.<sup>21</sup> In ways that historians have yet to map, by Haeckel's day the range of styles was much greater, and abstractions from individual peculiarities could be vivid too (Figure 2, *C–D*). He strongly selected relevant features. For example, the remains of the yolk sac and allantois that, with their incidental details, still dominate the Kölliker wood engraving after Bischoff (Figures 2, *B* and 3, *A*) are much

<sup>19</sup> Wilhelm His, *Unsere Körperform und das physiologische Problem ihrer Entstehung: Briefe an einen befreundeten Naturforscher* (Leipzig: Vogel, 1874), p. 170. Vogt dispensed with credits altogether; for a justification see his *Physiologische Briefe* (cit. n. 14), pp. 10–11. Huxley acknowledged only some borrowings; see legend to Figure 3.

<sup>20</sup> For the proposal see Richardson and Keuck, "Haeckel's ABC of Evolution and Development" (cit. n. 1), p. 521. Ecker described this specimen as five, not four, weeks old. For Haeckel's account see Haeckel to Carl Theodor von Siebold, 4 Jan. 1869 (Haeckel wrote "1868"), EHH. Here is the whole passage, from which I translate further below: "Was die von Bischoff gerügte zu große Ähnlichkeit der Embryonen von Mensch und Hund betrifft, so erklärt sich diese einfach daher, daß ich die beiderlei Embryonen auf meinen Tafeln (S. 240, b, c) auf gleiche Größe reducirt, in gleiche Stellung gebracht, und in gleicher Manier ausgeführt habe. Im Übrigen sind die Formen derselben ganz genau theils nach der Natur copirt, theils aus allen, bisher über diese frühen Stadien bekannt gewordenen Abbildungen zusammengestellt. Dabei möchte ich Bischoff noch besonders darauf aufmerksam machen, daß die verschiedenen Abbildungen menschlicher Embryonen von gleichem Alter (aus der IV–VIII Woche) bei den verschiedenen Autoren unter sich mehr verschieden sind, als von den Hunde-Embryonen gleichen Alters! Dies kann man schon aus den Embryonen-Tafeln in Eckers "Icones physiolog." sehen! Übrigens wird Bischoff wohl selbst nicht läugnen wollen, daß in einem wenig früheren Stadium *geradezu gar keine* Unterschiede zwischen Mensch und Hund vorhanden sein können!"

<sup>21</sup> Daston and Galison, "Image of Objectivity" (cit. n. 5), pp. 88–98; see also Lorraine Daston, "Type Specimens and Scientific Memory," *Critical Inquiry*, 2004, 31:153–182. Haeckel has long been seen as an artist as much as a scientist, but attention has focused on his 1904 "Art Forms in Nature." See Christoph Kockerbeck, *Ernst Haeckels "Kunstformen der Natur" und ihr Einfluß auf die deutsche bildende Kunst der Jahrhundertwende: Studie zum Verhältnis von Kunst und Naturwissenschaften im Wilhelminischen Zeitalter* (Frankfurt: Lang, 1986); Erika Krauß, "Haeckel: Promorphologie und 'evolutionistische' ästhetische Theorie: Konzept und Wirkung," in *Die Rezeption von Evolutionstheorien im 19. Jahrhundert*, ed. Eve-Marie Engels (Frankfurt am Main: Suhrkamp, 1995), pp. 347–394; Bernd Lötsch, "Gibt es Kunstformen der Natur? Radiolarien: Haeckels biologische Ästhetik und ihre Überschreitung," in *Welträtsel und Lebenswunder*, ed. Aescht *et al.* (cit. n. 8), pp. 339–372; Rainald Franz, "Stilvermeidung und Naturnachahmung: Ernst Haeckels 'Kunstformen der Natur' und ihr Einfluß auf die Ornamentik des Jugendstils in Österreich," *ibid.*, pp. 475–480; and Olaf Breidbach, "Kurze Anleitung zum Bildgebrauch," in Ernst Haeckel, *Kunstformen der Natur*, ed. Breidbach (Munich: Prestel, 1998), pp. 7–16.



reduced in the Huxley woodcut (Figure 3, C) and in Haeckel's drawing are completely suppressed (Figure 4, A). This simplification mattered, because it eliminated structures that distinguish higher from lower vertebrates. While the greater crudity of Huxley's copied illustrations fits their increased schematization, Haeckel's embryos are more dramatic and more schematic. He may have scaled wall charts down or planned to blow the drawings up.<sup>22</sup>

Haeckel reckoned privately in 1868 that his drawings were both exact and synthetic, but, accused of passing off "crude schemata" as evidence, reverted in public defenses to his frequent criticism of excessive exactitude. Not intended to be exact, the drawings were indeed "schematic," like von Baer's and the great majority of pedagogical figures.<sup>23</sup> Now, expository illustrations could all count as "schemata"; suppressing detail to focus on essentials helped figures based on individuals stand for all embryos of a particular species and stage. The difficulty is that in atlases and textbooks "schematic" referred more specifically to the small subset of highly simplified line drawings that clarified relationships or speculated about structures not yet observed. Trying to keep these off his plates, Ecker had most of them printed as wood engravings on the separate pages of legends, while Kölliker used only a few, all labeled as such (Figure 3, B). Haeckel's drawings look nothing like this, but he appears to have enjoyed the freedom of the specific sense of "schematic," only to exploit the wide meaning in his defense.<sup>24</sup>

Haeckel's other main justification took the charge of drawing to suit his theories and found it naive. Every schematic necessarily distorted the real form to give a scientist's view of its essence.<sup>25</sup> Yet the casual assumption that Haeckel's pictures of vertebrate embryos must primarily express the doctrine of recapitulation is misleading. They more obviously show the von Baerian view that vertebrate embryos begin similarly and then diverge because nature first lays out the general plan of the type. Von Baer had reported not being able to tell two unlabeled specimens apart and insisted that reptiles, birds, and mammals were indistinguishable even at an early limb-bud stage. Haeckel argued in the

<sup>22</sup> Haeckel used charts for a lecture in Berlin later that year; see Ernst Haeckel to Agnes Haeckel, née Huschke, 19 Dec. 1868, in *Ernst und Agnes Haeckel: Ein Briefwechsel*, ed. Konrad Huschke (Jena: Urania, 1950), p. 56.

<sup>23</sup> Rüttimeyer, rev. of Haeckel, *Ueber die Entstehung und den Stammbaum des Menschengeschlechts and Natürliche Schöpfungsgeschichte* (cit. n. 14); and Ernst Haeckel, *Ziele und Wege der heutigen Entwicklungsgeschichte* (Jena: Dufft, 1875), pp. 37–38.

<sup>24</sup> Haeckel referred to his own figures in the *Generelle Morphologie der Organismen: Allgemeine Grundzüge der organischen Formen-Wissenschaft, mechanisch begründet durch die von Charles Darwin reformirte Descendenz-Theorie*, 2 vols. (Berlin: Reimer, 1866; facsimile ed., Berlin: de Gruyter, 1988), Vol. 1: *Allgemeine Anatomie der Organismen: Kritische Grundzüge der mechanischen Wissenschaft von den entwickelten Formen der Organismen, begründet durch die Descendenz-Theorie*, p. 559, as "schematic outlines" in the narrow sense; for the term applied generally and positively to the illustrations in his *Anthropogenie* see Carl Hasse to Haeckel, 19 Oct. 1874, EHH. See also Alexander Ecker, *Hundert Jahre einer Freiburger Professoren-Familie: Biographische Aufzeichnungen* (Freiburg i. B.: Mohr, 1886), pp. 140–141: "for even seeing, especially seeing through a microscope, must be learned and for this purpose schematic drawings serve above all else. . . . Of course, however, such blackboard drawings can only be linear sketches. . . . Complicated schemata, physical, perspectival drawings with shade and light cannot be done by hand; for this purpose carefully executed plates on a larger scale are called for."

<sup>25</sup> Ernst Haeckel, "Apologetisches Schlusswort," in *Anthropogenie oder Entwicklungsgeschichte des Menschen: Keimes- und Stammes-Geschichte*, 4th ed., 2 parts (Leipzig: Engelmann, 1891), Pt. 2: *Stammesgeschichte des Menschen: Wissenschaftliche Vorträge über die Grundzüge der menschlichen Phylogenie*, pp. 857–864, on pp. 859–860; and Sapp, *Where the Truth Lies* (cit. n. 2), pp. 17–20. Some admirers excused Haeckel's schemata as the products of the all too lively, synthetic fantasy that was also responsible for his many positive contributions, a view his personal assistant rejected; see Schmidt, *Haeckels Embryonenbilder* (cit. n. 1), pp. 66, 68, 88.

same early letter in which he discussed his sources that humans and dogs must start the same, leaving room for debate only over when they diverged. Von Baer had also written of the obstacles that individual variation put in the way of understanding development within species. Haeckel appealed to the widespread suspicion that many of the early human embryos in the literature were abnormal and poorly described; even the drawings in Ecker's atlas differed more among themselves than from dog embryos of the same age, he claimed.<sup>26</sup>

Crucially, Haeckel drew types, not of a generalized vertebrate, but of four species that he lined up. He "reduced both [dog and human] embryos . . . to the same size, brought them into the same position, and executed them in the same manner."<sup>27</sup> Photographically assembling some of Haeckel's models (Figures 2 and 3) makes clear how much further he went. Drawing at the same size entailed magnifying different embryos by different amounts, drawing in the same position could involve deducing how an embryo looked from the other side, and drawing in the same manner meant imposing a style. Such aggressive redrawing vividly presented a conclusion but also began to set up a framework within which differences and similarities were open to scrutiny as never before.

So Haeckel relied on embryology but knew that it put many students off. Lacking comparative illustrations, he sought to make vivid the embryological evidence for common descent. His drawings certainly pushed the limits of accepted practice, even among professors addressing lay audiences, but miscopying is harder to prove than is usually assumed and I have found no reason to suspect deception. The comparative framework is more significant. It began with his heavily reworked pairs and would become even bolder on the printed page.

#### PRINTING VISUAL FACTS

Letters between Haeckel and the Reimers as they worked to illustrate the book give access to concerns that overlap little with those of Haeckel's accusers. The correspondence also helps reconstruct the procedures by which the original drawings were turned into the wood engravings and lithographs and brought together with the text. While new printing technologies could go hand in hand with novel modes of scientific representation, the *Schöpfungsgeschichte* was, or should have been, technically undemanding. Driven by Haeckel's interest in communicating ontogeny and phylogeny to a wide audience, the power of the illustrations was in the design.<sup>28</sup>

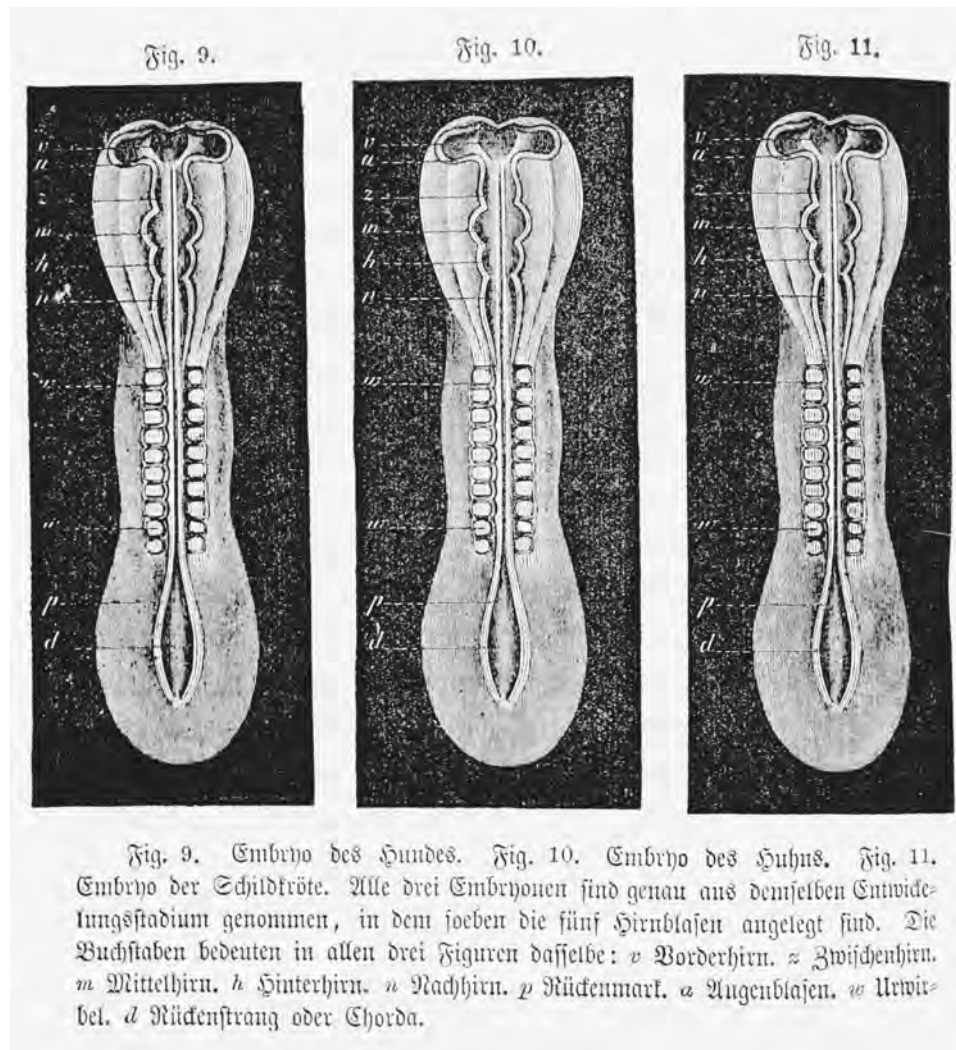
In March 1868 Haeckel sent Georg Reimer twelve drawings, six for the comparative embryological plate (Figure 4) and six (which, as far as I know, have not survived) for the

<sup>26</sup> Haeckel to Siebold, 4 Jan. 1869 (cit. n. 20); and Karl Ernst von Baer, *Über Entwicklungsgeschichte der Thiere: Beobachtung und Reflexion*, 2 parts, Pt. 1 (Königsberg: Gebrüder Bornträger, 1828; facsimile ed., Brussels: Culture et Civilisation, 1967), pp. 4–6 (individual variation), 221 (unlabeled embryos).

<sup>27</sup> Haeckel to Siebold, 4 Jan. 1869.

<sup>28</sup> The Reimers disliked Haeckel's "strong hint of godlessness" and worried as they read the proofs that it would prejudice enlightened Christians against him (Ernst Reimer to Haeckel, 5 June 1868, EHH), but they did not raise the accusations against his figures in the letters. They probably believed that as laymen and publishers it was best to keep out of scientific disputes (see E. Reimer to Haeckel, 19 July 1878, EHH, on the Haeckel–Virchow controversy), and they might have chosen to raise delicate issues face to face. For cases in which new technologies were crucial see, e.g., Alex Soojung-Kim Pang, "Victorian Observing Practices, Printing Technology, and Representations of the Solar Corona," *Journal for the History of Astronomy*, 1994, 25:249–274, 1995, 26:63–76; and Phillip Prodger, "Illustration as Strategy in Charles Darwin's 'The Expression of the Emotions in Man and Animals,'" in *Inscribing Science*, ed. Lenoir (cit. n. 4), pp. 140–181.

fourteen wood engravings in the text. Of these, only the last, a radiolarian of Haeckel's own, is unique; a moner and an amoeba appear twice each, a mammalian egg four times, its cleavage twice, and a vertebrate embryo three times. Repetition was common in textbooks and popular works to save page-turning and make blocks go further. But it was not usual for one block to represent the "egg of a mammal" as well as those of human, ape, and dog and for another to stand for the embryos of dog, chick, and turtle (Figure 5). Presumably galvanoplastic stereotypes (clichés) were used to reproduce pictures three



**Figure 5.** Embryos of dog, chick, and turtle "taken exactly from the same stage of development, in which the five brain-bladders have just begun to form." Wood engraving by Johann Gottfried Flegel after a drawing, probably by Ernst Haeckel, printed three times by Johannes Friedrich Frommann. The right-hand side is a little distorted here because it is close to the original gutter. Haeckel's drawing was based on pictures such as are reproduced in Figure 2, A and C, of this article. From Ernst Haeckel, *Natürliche Schöpfungsgeschichte* (Berlin: Reimer, 1868), figures 9–11 on page 248.

times in a single printing on one page. This was reckless, but since incontestable malpractice was easily discoverable by close inspection of incidental details it is unlikely that Haeckel intended to deceive. He corrected the figures in the next (1870) edition and in 1891 excused this “extremely rash *foolishness*” as committed in undue haste but “*bona fide*.”<sup>29</sup>

Haeckel may have been in a hurry, but he and the Reimers took some trouble to have the wood engravings cut well. Wanting “softness and delicacy,” he asked for Johann Gottfried Flegel of Leipzig, Kölliker’s wood engraver, and was delighted with the “very good” proofs. The only problem came from entrusting the “not difficult” printing job to the Jena printer Johannes Friedrich Frommann. Though he played a leading role in organizing the book trade, Frommann’s contempt for innovation inflicted a steady decline on his own business, and he had not printed any wood engravings for twenty or thirty years. After he smeared the first figures, making them “unrecognizable,” the Reimers had Haeckel intervene, and with finer ink the rest came out much better. Haeckel had planned to have the plate reproduced by wood engraving too, but Frommann and the local lithographer, Eduard Giltsch, persuaded him not only that this would “never achieve the *softness* of the forms” but also that, since these figures were to be printed larger—and presumably also because the run was only 1,000—lithography would be “*better and cheaper*.” Reimer agreed.<sup>30</sup>

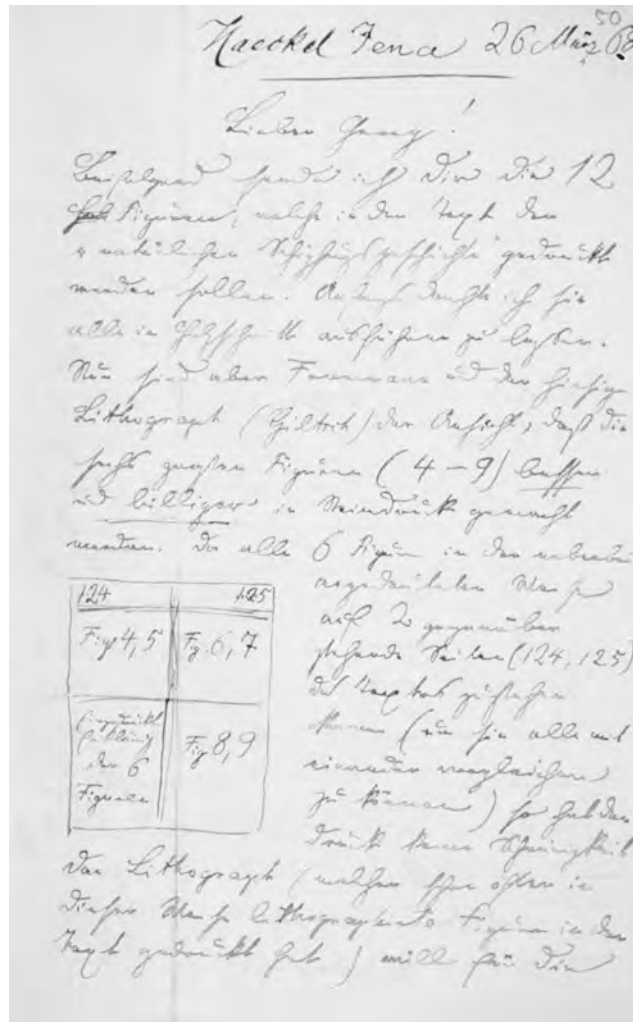
Thus began the series of printings that created the most powerful and problematic of comparative embryological illustrations. Giltsch or his son Adolf probably brought the pairs of drawings (Figure 4) together on a double plate in the arrangement Haeckel had sketched (Figure 6). The background is blacker, and the lines are inevitably harder, but the rendition is faithful (Figure 7).<sup>31</sup> The drawings and this rarely reproduced lithograph show that the definitive design was created in several steps. In the next edition a fourth pair was added and rows were made to represent stages in the development of a vertebrate series (Figure 8). Not until the *Anthropogenie* did Haeckel eliminate the horizontal division across the pages and give species labels that unify the columns (see Figure 12, below). He also expanded what was now a double-developmental array to three stages for eight—and by the fifth edition, twenty—species. Though related, if perhaps not strictly equivalent, images were available, for example, in physiognomy, Haeckel did not have some obvious model for rows and columns ready to import; he and his collaborators built up a new design from pairs as they went along. The embryonic grid then created a space of representation that made Haeckel’s assumptions potent: most basically, that common stages could be set up between species. Near-identity in the first row may have seemed aesthetically desirable to heighten the effect of divergence, and he was encouraged to fill cells

<sup>29</sup> Haeckel, “Apologetisches Schlusswort” (cit. n. 25), pp. 861–862. The figures are in Haeckel, *Natürliche Schöpfungsgeschichte* (cit. n. 17), pp. 146, 242, 248.

<sup>30</sup> Haeckel to G. Reimer, 26 Mar. 1868, SBB (for “softness and delicacy”). For the other points see G. Reimer to Haeckel, 27 Mar. 1868 (“not difficult”), and E. Reimer to Haeckel, 5 June 1868 (“unrecognizable”), EHH; and Haeckel to G. Reimer, 4 May 1868 (“very good”), and Haeckel to E. Reimer, 22 June 1868 (Frommann’s lack of practice and Haeckel’s intervention), SBB. On Frommann see Gerhard Menz, *Deutsche Buchhändler: Vierundzwanzig Lebensbilder führender Männer des Buchhandels* (Leipzig: Werner Lehmann, 1925), pp. 75–82, on p. 78; and Frank Wogawa, “‘Zu sehr Bürger . . .’? Die Jenaer Verleger- und Buchhändlerfamilie Frommann im 19. Jahrhundert,” in *Bürgertum in Thüringen: Lebenswelt und Lebenswege im frühen 19. Jahrhundert*, ed. Hans-Werner Hahn, Werner Greiling, and Klaus Ries (Rudolstadt: Hain, 2001), pp. 81–107.

<sup>31</sup> Giltsch had recommended lithography for the embryo plate, but the lithographer Gustav Müller, who appears to have lived and worked separately (Frau Mann, Stadtarchiv Jena, to Nick Hopwood, 9 Mar. 2006), did the frontispiece (unsatisfactorily) later that summer; see E. Haeckel to A. Haeckel, 31 Aug. 1868, in *Ernst und Agnes Haeckel*, ed. Huschke (cit. n. 22), p. 49. On the Giltsches, but with no mention of this job, see Ernst Haeckel, “Adolf Giltsch: Ein Nachruf,” *Altes und Neues aus der Heimat: Beilage zum Jenaer Volksblatt*, 1911, no. 11.





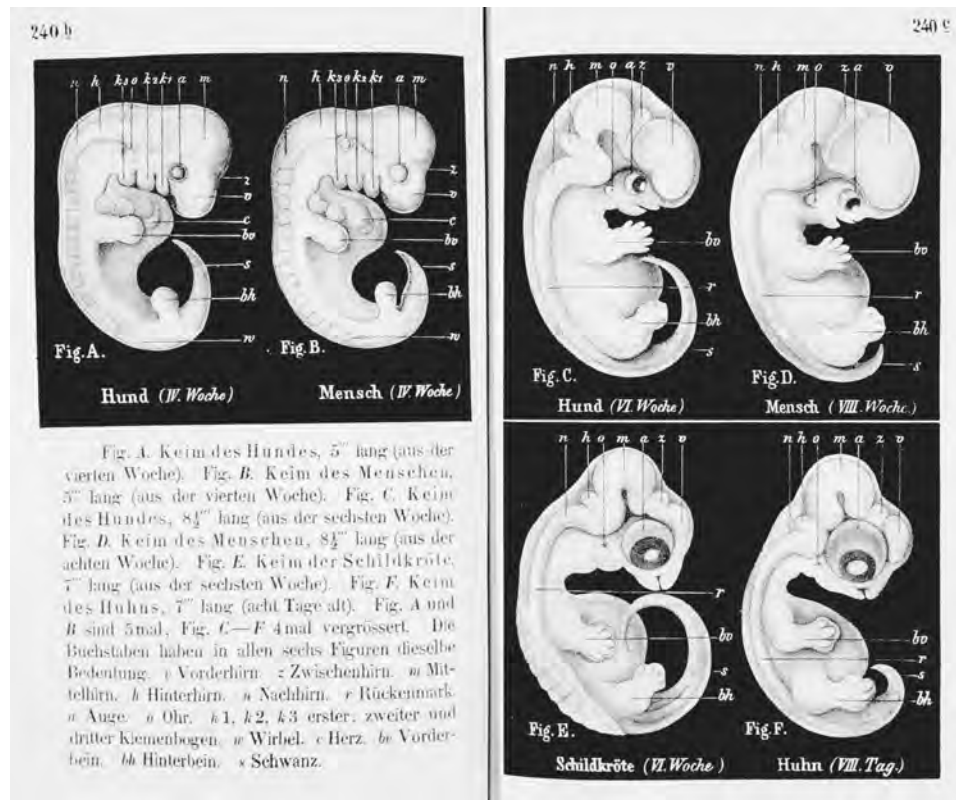
**Figure 6.** Haeckel's sketch in a letter to his publisher, Georg Reimer, of the arrangement of drawings for the double embryological plate in the *Natürliche Schöpfungsgeschichte*. The figures (A–F in Figure 7 of this article) were then still numbered 4–9 in one series with the future wood engravings. From Ernst Haeckel to Georg Reimer, 26 March 1868, Staatsbibliothek zu Berlin—Preussischer Kulturbesitz: Dep. 42 (Archiv Walter de Gruyter), R1: Haeckel, Ernst, Bl. 50r.

for which no reliable material was to hand with deductions he regarded as heuristic. But all this lay in the future; in 1868 he anticipated “great interest” from putting just six figures together.<sup>32</sup>

Bound into the finished volume, the illustrations clearly aimed to provoke. Ernst Reimer

<sup>32</sup> Haeckel to G. Reimer, 26 Mar. 1868, SBB. The legends refer to “rows” (*Querreihen*), but not columns. On physiognomical developmental series see Karl Clausberg, “Psychogenese und Historismus: Verworfenne Leitbilder und übergangene Kontroversen,” in *Natur der Ästhetik, Ästhetik der Natur*, ed. Olaf Breidbach (Vienna: Springer, 1997), pp. 139–166; and Uwe Schögl, “Vom Frosch zum Dichter-Apoll: Morphologische Entwicklungsreihen bei Lavater,” in *Das Kunstkabinett des Johann Caspar Lavater*, ed. Gerda Mraz and Schögl (Vienna: Böhlau, 1999), pp. 164–171.





**Figure 7.** Comparative embryological lithograph from Haeckel's *Natürliche Schöpfungsgeschichte* (Berlin: Reimer, 1868), pages 240b–c. The panels show, in his terms, (A) germ of the dog (from the fourth week); (B) germ of the human (from the fourth week); (C) germ of the dog (from the sixth week); (D) germ of the human (from the eighth week); (E) germ of the turtle (from the sixth week); and (F) germ of the chick (eight days old). Haeckel states that on his plate A–B are five times and C–F four times enlarged. Panel A–B is 8.6 × 10.1 cm.

had turned down Haeckel's request for a special color cover to "excite attention" by depicting "the fundamental idea of the whole evolutionary tree" as too hard for the Jena lithographers and out of fashion for serious literature. Instead, he grabbed readers with an inflammatory frontispiece that paired heads of human races and manlike apes (Figure 9). The embryological plates at which, thanks to the thicker paper, the book tends to fall open also express the key claim about human origins. Giving a polemical edge to von Baer's lament that his listeners would all know that cackling geese had saved Rome but only the medics would have examined a goose egg inside, Haeckel lambasted the humanistic bias of the schools. "Our so-called 'educated' circles" and even many zoologists, he scolded, either knew nothing of "these invaluable facts of human ontogeny" or failed to recognize that they "would alone be sufficient to solve the question of man's position in nature and thus the highest of all problems." "Contemplate attentively and compare the six figures which are reproduced on the following plates" (Figure 7), Haeckel urged, "and you will recognize that one cannot rate the philosophical importance of embryology highly enough." "What," he thundered, were hereditary nobles to "think of the thoroughbred blood that circulates in their privileged veins, when they learn that all human embryos,



**Figure 8.** "Germes or embryos of four vertebrates." Turtle, chick, dog, and human embryos are shown from left to right at (first row) an earlier and (second row) a later stage. Olive-green lithograph from Ernst Haeckel, *Natürliche Schöpfungsgeschichte*, 2nd edition (Berlin: Reimer, 1870), Plates II–III.

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?"<sup>33</sup>

Haeckel used the pictures here mainly to present von Baerian laws of differentiation and progress from crucially similar beginnings. Huxley had qualified a similarly venerable claim—"ordinary inspection would hardly distinguish" early vertebrate embryos that were alike "in all essentials"—but Haeckel insisted—of the figures derived from a single block—that "if you compare the young embryos of the dog, the chick, and the turtle in

<sup>33</sup> Haeckel, *Natürliche Schöpfungsgeschichte* (cit. n. 17), pp. 239–240; and von Baer, *Über Entwicklungsgeschichte der Thiere* (cit. n. 26), Pt. 2 (Königsberg: Gebrüder Bornträger, 1837; facsimile ed., Brussels: Culture et Civilisation, 1967), p. 8. For the proposed cover see Haeckel to E. Reimer, 22 June 1868, SBB; and E. Reimer to Haeckel, 23 June 1868, EHH. On the frontispiece see Di Gregorio, *From Here to Eternity* (cit. n. 4), pp. 249–252, which applies Gegenbaur's criticism of an illustration in the *Anthropogenie* to this plate. Writing from a holiday in the Tyrol, Haeckel was unhappy that the lithographer Müller's proof strayed too far from his original. He asked his wife Agnes, an anatomist's daughter, to have figure 1, in particular, corrected and the eyes made "more expressive throughout." She and Müller judged the plate "in general quite successful," but she agreed that the eyes were "too expressionless" and checked a revision. See E. Haeckel to A. Haeckel, 31 Aug. 1868, and A. Haeckel to E. Haeckel, 6 Sept. 1868, in *Ernst und Agnes Haeckel*, ed. Huschke (cit. n. 22), pp. 49, 50–51. The frontispiece was apparently the last item finished; Haeckel checked the embryo plates in Jena himself: Haeckel to E. Reimer, 22 June 1868, SBB.



**Figure 9.** Frontispiece and title page of Haeckel's *Natürliche Schöpfungsgeschichte* (Berlin: Reimer, 1868). "The family group of the catarrhines" was notoriously supposed (page 555) to demonstrate "the highly important fact" that the "lowest humans" (figures 4–6, "Australian Negro," "African Negro," and "Tasmanian") stood "much nearer" to the "highest apes" (figures 7–9, gorilla, chimpanzee, and orang) than to the "highest human" (figure 1, "Indo-German"). The lithograph, by Gustav Müller, also shows "Chinese" (figure 2), "Fuegian" (figure 3), gibbon (figure 10), proboscis monkey (figure 11), and mandrill (figure 12).

figs. 9, 10, and 11 [here Figure 5], you will not be able to perceive a difference." The first differences were in molecular composition alone. The later stages on the plates (Figure 7) displayed differentiation and progress, but these did not always go together, as rudimentary organs showed. Tailed embryos were an "irrefutable witness for the undeniable fact" of human descent from tailed ancestors. Haeckel went on to draw out both a standard transformist analogy—ontogeny was more remarkable than phylogeny, yet occurred every day—and the recapitulationist claim that the connection was causal. This licensed his use of embryological evidence in the construction of systematic tables and the evolutionary trees at the back of the book. He presented these as an "approximate hypothesis" of organisms' genealogical relations that contained most of his original research. By contrast, deploying the word "fact" eleven times in the four pages of text around the embryo plate, he treated the embryological illustrations as providing readers with established knowledge ripe for evolutionary reinterpretation.<sup>34</sup>

<sup>34</sup> Haeckel, *Natürliche Schöpfungsgeschichte*, pp. 235 (tailed embryos), 238–241 (uses of "fact"), 249 (figs. 9–11), 317 ("approximate hypothesis"); and Thomas Henry Huxley, *Evidence as to Man's Place in Nature* (London: Williams & Norgate, 1863), pp. 64–65.

The *Schöpfungsgeschichte* traded on Haeckel's boldness in applying evolution to human beings and had text and illustrations to match. More than with the embryos' specific forms, he courted controversy with the unprecedentedly comparative frame and exaggerated claims. Pictures that, except for the repeated blocks, might have been unproblematic as schematics appeared with exhortations to treat them as evidence.

**“DRAWN . . . RATHER FREELY”?**

How would Haeckel's embryological illustrations fare among his peers, the professors of anatomy and of zoology who also taught embryology in the universities? It is true that “expert contemporaries recognized what he had done, and said so in print,” but competent readers did not immediately and unanimously see any problem. Something approaching forgery first became an issue in late 1868, when a few faced a conflict between what they saw and what they knew and one went public. The opposed responses of other embryology teachers tell clearly how past experience and present agendas determined professors' initial positions.<sup>35</sup>

From the University of Munich, where Haeckel had enjoyed an unexpectedly friendly personal reception earlier in the year and his book had sold out, a rich account contrasts the reactions of the anatomist Theodor Bischoff and the zoologist Carl von Siebold. Co-editor of his discipline's leading journal, Siebold had made a name by championing his observation of parthenogenesis in bees against the newly dominant theory that demanded the action of semen. He complained about Haeckel's dogmatism and repeatedly advised his young friend to learn from criticism, but he also acknowledged a kindred spirit in challenging dogma. Writing in late December 1868 to thank Haeckel for the book, Siebold proved his commitment to evolution by reporting how he “had to take up the cudgels for you against Bischoff,” who “mentioned your [embryo plates, here Figure 7], which for me allow one to recognize so clearly the kinship of all vertebrates, including man. Bischoff said you had drawn the human embryos rather freely, so that they came closer to the dog embryos. I do not believe this. Can you possibly tell me which figures you copied? I would be glad if I could show my colleague these original illustrations.” Siebold had grown up with embryology: the son and brother of obstetricians, he had taught midwifery and lectured on human generation. He most likely went into the conversation defending the plates but left it with the sense that he no longer mastered the literature, perhaps even with doubts of his own. Haeckel, who still hoped to succeed to Siebold's chair, devoted a whole page of his grateful response to the account from which I quoted earlier. Siebold behaved as though fully satisfied. Silent on the pictures, his next letter reported his successful proposal of Haeckel for membership in the Bavarian Academy of Sciences, an important source of funds. The two men soon moved to the familiar “Du.”<sup>36</sup>

Bischoff, most widely known today for his hostility to women's medical education, also

<sup>35</sup> Gould, “*Abscheulich!*” (cit. n. 1), p. 46. For professorial reading and reviewing see Secord, *Victorian Sensation* (cit. n. 6), pp. 222–260.

<sup>36</sup> Siebold to Haeckel, 28 Dec. 1868 (quotation; and the book's Munich success), 31 July 1870, and Haeckel to Siebold, 4 Jan. 1869, 22 Feb. 1873 (first *Duzen*), EHH. For Haeckel's Munich reception see E. Haeckel to A. Haeckel, 27 Aug. 1868, in *Ernst und Agnes Haeckel*, ed. Huschke (cit. n. 22), p. 47; for his wish to succeed Siebold see Uschmann, *Geschichte der Zoologie* (cit. n. 12), pp. 81–82. On Siebold see Ernst Ehlers, “Carl Theodor Ernst von Siebold: Eine biographische Skizze,” *Zeitschrift für Wissenschaftliche Zoologie*, 1885, 42:i–xxxiv; and Hans Körner, *Die Würzburger Siebold: Eine Gelehrtenfamilie des 18. und 19. Jahrhunderts* (Neustadt a. d. Aisch: Degener, 1967), pp. 291–355. On his relations to Haeckel see *ibid.*, pp. 324, 327–328; and Nyhart, *Biology Takes Form* (cit. n. 15), p. 186.



opposed Darwinism; in these very years he worked to widen the gap between the brains of humans and apes. As the leading pioneer of mammalian embryology, he was Haeckel's most authoritative possible critic. On the one hand, his surveys from around 1840 stressed how "extraordinarily similar" were the early embryos of man and other vertebrates. On the other, a decade later, startled by the extreme differences between early hamster development and that of rabbit and dog, he had inveighed against hasty generalization. Yet as far as we know he found fault only with Haeckel's pictures of human embryos, letting pass the dog that Haeckel would be accused of miscopying from him. Nor did Siebold report any criticism of the woodcuts; did their elderly eyes not notice anything unusual, or was it too embarrassing to mention (Figure 5)?<sup>37</sup>

Siebold and Bischoff introduce a pattern: the more hostile a reader was to Haeckel's Darwinism, and the more expert in vertebrate embryology, the more offensive he was apt to find the drawings. The other greatest authority was Louis Agassiz, the Swiss creationist at Harvard whose illustrations of turtle embryos Haeckel would be assumed to have copied. Agassiz's marginalia exploded at the comparative plate (Figure 7, A–B)—"Where copied from? Contrived similarity combined with inaccuracy"—and the younger embryos (Figure 5). Under Haeckel's claim that he would detect no difference, he wrote: "Naturally, since these figures were not drawn from nature, but rather one is copied from the other! Atrocious."<sup>38</sup> By contrast, Siebold, who was less knowledgeable but still generally competent in the field, broadly supported Haeckel and saw no reason to make a big issue of the pictures. Haeckel's contemporary, the Kiel physiologist Victor Hensen, who in a later row would throw the accusations of fraud at him, drew attention to "a series of instructive illustrations to demonstrate the similarity of young embryos of various vertebrates." Darwin simply noted, with reference to Haeckel's plate, "I must [k]no[w] about embryology."<sup>39</sup> Many life scientists could look at his pictures as confirming what they already knew or should know. Others experienced a worrying clash with their greater knowledge, but for a long time kept doubts more or less to themselves. Only one immediately went into print with accusations of foul play.

It is well known that the first forgery charges were leveled, also in late 1868, by Ludwig Rüttimeyer in the *Archiv für Anthropologie*. But why? Professor of zoology and comparative anatomy at the University of Basel, Rüttimeyer was a founding member of the German Anthropological Society, which owned the *Archiv* and would become a bastion of empiricist resistance to Darwinist speculation. He not unusually rejected natural selection as too

<sup>37</sup> Theodor Bischoff, "Entwicklungsgeschichte, mit besonderer Berücksichtigung der Mißbildungen," in *Handwörterbuch der Physiologie mit Rücksicht auf physiologische Pathologie*, ed. Rudolph Wagner, 4 vols., Vol. 1 (Braunschweig: Vieweg, 1842), pp. 860–928, on p. 893; and Bischoff, *Entwicklungsgeschichte des Meerschweinchens* (Giessen: Ricker, 1852), p. 7. On Bischoff see Christian Giese, "Theodor Ludwig Wilhelm von Bischoff (1807–1882): Anatom und Physiologe" (Habilitationsschrift, Justus-Liebig-Universität Giessen, 1990). Siebold would have to wait for daylight and often used a magnifying glass to decipher the wood engravings in the *Anthropogenie*: Siebold to Haeckel, 14 Feb. 1875, EHH.

<sup>38</sup> Gould, "Abscheulich!" (cit. n. 1), pp. 45, 49. Since, for Agassiz, particular turtles existed materially, but the species only as divine thoughts, representing individuals was a duty; see Ann Shelby Blum, *Picturing Nature: American Nineteenth-Century Zoological Illustration* (Princeton, N.J.: Princeton Univ. Press, 1993), pp. 210–227.

<sup>39</sup> Victor Hensen, "Generationslehre und Embryologie," *Jahresbericht über die Leistungen und Fortschritte in der Gesamten Medicin*, 1869, 3(1):56–65, on p. 58; and *Charles Darwin's Marginalia*, Vol. 1, ed. Mario A. Di Gregorio (New York: Garland, 1990), col. 358. Though the *Jahresbericht* was a bland annual report, evaluations were given, including by Hensen. For his later accusations see Hensen, *Die Planktonexpedition und Haeckel's Darwinismus: Ueber einige Aufgaben und Ziele der beschreibenden Naturwissenschaften* (Kiel: Lipsius & Tischer, 1891), pp. 9–11.



mechanistic, and his antimaterialist view of the history of nature as a progressive striving for consciousness left the natural sciences only a modest place in the order of knowledge. But Rüttimeyer accepted human evolution and in the early 1860s had been one of the first to place fossil mammals in evolutionary lineages. Darwin commented in 1865, “I think Rüttimeyer, for whom I have the greatest respect, is also with us.” Haeckel asked the Reimers to send Rüttimeyer the *Schöpfungsgeschichte* “on behalf of the author.”<sup>40</sup>

Reviewing the book together with a lecture by Haeckel in Virchow’s series, Rüttimeyer concentrated on the difficulty of classifying the works. “The author has called them popular and scholarly,” evidently a puzzling combination; “no one will dispute the correctness of the first predicate, but he will himself hardly lay serious claim to the second.” The most generous assessment might be to call them “schemata, how the author imagines our present knowledge arranged in the future; they thus form a kind of . . . fantasy literature.” Rüttimeyer was horrified that such public discussion of man’s place in nature would allow the uneducated to ferment atheism and materialism from the unripe fruits of zoological research, but he reassured a Basel audience: “The work itself is much too difficult and requires much too much the concerted exercise of all the powers of our mind for it to be able to proceed anywhere else than in the quiet room, closed against the incompetent, of one who sees clearly and thinks deeply.”<sup>41</sup> He would certainly have preferred Haeckel’s pictures to be held under lock and key.

Rüttimeyer wondered if the figures were “intended to secure the book, alongside the audience which reads the text and then if necessary makes its own such illustrations, a second whom one wanted . . . to spare the reading.” “They neither create the impression of being intended to last, nor are they altogether new.” He deplored the publication of the frontispiece, a kind of drawing “well enough known in convivial circles of friends,” and of the evolutionary trees, hypothetical “sketches” such as had long existed “for private orientation . . . in desk drawers” and should have remained there. Against the embryological drawings, which were “really new in a certain sense,” the distinct charge was that Haeckel had taken two kinds of liberty with established truth. No more than Siebold did Rüttimeyer insist on illustrations directly after specimens, but given that “drawings in no other field . . . demand greater scrupulosity and conscientiousness,” it could have been expected that Haeckel “not arbitrarily model or generalize his originals for speculative purposes”—as comparison of the lithographs with works by Bischoff, Ecker, and Agassiz proved. Worse, “one and the same, moreover incorrectly interpreted woodcut, is presented to the reader three times in a row and with three different captions as [the] embryo of the dog, the chick, [and] the turtle.” This sort of thing could be disregarded in “sixth- and

<sup>40</sup> Haeckel to E. Reimer, 19 Oct. 1868, EHH. Haeckel either judged that Rüttimeyer would like the book or wanted to make it harder for him to attack it. On Rüttimeyer see Carl Schmidt, “Ludwig Rüttimeyer,” *Verhandlungen der Schweizerischen Naturforschenden Gesellschaft*, 1896, 78:213–256; L. E. Iselin, *Carl Ludwig Rüttimeyer* (Basel: Reich, 1897), p. 29 (Darwin quotation); Eduard His, *Basler Gelehrte des 19. Jahrhunderts* (Basel: Schwabe, 1941), pp. 202–212; and Clifford M. Nelson, “Karl Ludwig Rüttimeyer,” in *Dictionary of Scientific Biography*, 18 vols., Vol. 12, ed. Charles Coulston Gillispie (New York: Charles Scribner, 1975), pp. 37–39. On anthropological empiricism see Andrew Zimmerman, *Anthropology and Antihumanism in Imperial Germany* (Chicago: Univ. Chicago Press, 2001).

<sup>41</sup> Rüttimeyer, rev. of Haeckel, *Ueber die Entstehung und den Stammbaum des Menschengeschlechts und Natürliche Schöpfungsgeschichte* (cit. n. 14); and Ludwig Rüttimeyer, “Die Grenzen der Thierwelt: Eine Betrachtung zu Darwin’s Lehre: Zwei in Basel gehaltene Vorträge, 1868,” in *Gesammelte kleine Schriften allgemeinen Inhalts aus dem Gebiete der Naturwissenschaft: Nebst einer autobiographischen Skizze*, ed. Hans G. Stehlin, 2 vols. (Basel: Georg, 1898), Vol. 1: *Autobiographie. Zoologische Schriften*, pp. 225–288, on p. 254. University professors tended to judge Haeckel’s books accessible; see Daum, *Wissenschaftspopularisierung im 19. Jahrhundert* (cit. n. 4), p. 307.

seventh-hand compilations,” but not in a microscopist’s “‘scientific’ history of creation,” especially when he “does not describe these drawings as crude schemata” but states that “‘you will not be able to perceive a difference.’” Rüttimeyer did not write of “‘forgery,’” let alone “‘fraud,’” but of “‘playing fast and loose with the public and with science.’” His sentences, as difficult to negotiate as an Alpine torrent, might have been designed to restrict his comments to the attention of the competent few. But to them he protested clearly enough that Haeckel had failed to live up to the “obligation” to the “truth” that should live “inside every serious researcher.” Rüttimeyer also denied the pictures any honest originality.<sup>42</sup>

Rüttimeyer had his own backbone, but he surely took advice from the close colleague who had spent the previous two-and-a-half years applying new microscopical, drawing, and modeling techniques to chick embryos and whose embryology course Rüttimeyer attended that very winter. No one had a stronger disciplinary interest in opposing Haeckel’s embryology than Basel’s professor of anatomy and physiology, Wilhelm His. About the same age as Haeckel, he had shared important teachers in Würzburg and Berlin but was now allied with his most dangerous scientific enemies. His had just developed an approach that combined morphologists’ high estimation of embryology with physicalist physiologists’ withering views of the morphological “explanations” on which Darwinism seemed to offer no great advance. Instead, he treated the embryo as a problem in analytical mechanics and derived its form from the pressures and pulls set up by differential growth. So though favorably disposed to the descent hypothesis, he did not see embryology as the most compelling evidence and sought “to safeguard the claims of the individual history of development from the overflowing power of Darwinian views.” In an address to the University of Basel in late 1869 His also insisted, in a significant modification of von Baer’s views, that “complete identity of forms is not found even at very early stages of development or for closely related embryos. The more practiced an observer is, the earlier he will know to assign a doubtful object to its appropriate place.” Just as His deferred to his senior colleague as the authority on Darwinism, it would be surprising had Rüttimeyer not sought reassurance from the expert who in 1875 would come out as Haeckel’s chief embryological accuser.<sup>43</sup>

Beyond their disciplinary concerns—His was on the board of the *Archiv für Anthropologie* too—he and Rüttimeyer shared a local audience that helps explain their attacks. Haeckel saw Rüttimeyer as truckling to religion for money. “Since his excellent works have earned him the reputation of being almost a Darwinist,” he slandered “other Darwinists” so that his “very clerically pious” Basel countrymen would still pay his salary.<sup>44</sup> That is too crude, for Basel scholars valued authenticity above all else. But the Swiss city-republic

<sup>42</sup> Rüttimeyer, rev. of Haeckel, *Ueber die Entstehung und den Stammbaum des Menschengeschlechts* and *Natürliche Schöpfungsgeschichte*; it is not clear in what respect the woodcuts were supposed to be misinterpreted. Darwin also made genealogical trees in private; see Voss, *Darwins Diagramme* (cit. n. 3), p. 41.

<sup>43</sup> Rüttimeyer’s attendance at the course on “Entwicklungsgeschichte” in winter 1868/1869 is documented in an “Inskriptionsbuch der Studenten von W. His, WS 1856/57 bis SS 1872,” Öffentliche Universitätsbibliothek Basel: His Papers (Nachlaß 229), 13. On His’s mechanical embryology see Nick Hopwood, “‘Giving Body’ to Embryos: Modeling, Mechanism, and the Microtome in Late Nineteenth-Century Anatomy,” *Isis*, 1999, 90:462–496. The address is Wilhelm His, *Ueber die Bedeutung der Entwicklungsgeschichte für die Auffassung der organischen Natur: Rectoratsrede, gehalten den 4. November 1869* (Leipzig: Vogel, 1870), pp. 35, 24. For his deference see His, *Untersuchungen über die erste Anlage des Wirbelthierleibes: Die erste Entwicklung des Hühnchens im Ei* (Leipzig: Vogel, 1868), pp. 223–224; see also His, “Ludwig Rüttimeyer,” *Anatomischer Anzeiger*, 1896, 11:508–512.

<sup>44</sup> Haeckel to Charles Darwin, 12 Oct. 1872, Cambridge University Library, MSS.DAR.166:58; Haeckel also likened the “pseudo-Darwinist” Rüttimeyer to “a dog that barks because it is annoyed at a fast horse running past.”

was ruled by an oligarchy of pietists and millionaires that in the mid-nineteenth century created conditions for critical intellectual engagement with the modernizing world. For the humanities, Lionel Gossman has characterized Basel as a haven for “unseasonable ideas,” “a sanctuary for intellectual practices that ran counter to the reigning orthodoxies of German scholarship.” Rütimeyer and His do not entirely fit this picture but did impress their Basel audience, which also had little interest in science popularization, with their courage in resisting a rising orthodoxy perceived as artificial, populist, and gratuitously offensive to religion.<sup>45</sup>

These early responses show that, like Haeckel’s system as a whole, his embryological illustrations divided his peers from the start. They also indicate a pattern. The critics, who largely agreed as to what was wrong, were all expert in vertebrate embryology—Rütimeyer had easy access to such expertise—and hostile, for disciplinary, political, and religious reasons, to Haeckel’s brand of *Darwinismus*. I cannot separate competence and stance on evolution, because I know of no similarly established vertebrate embryologist who embraced his views. By contrast, those who either welcomed the pictures or did not take opportunities to criticize them tended to be only generally competent and favorably disposed toward Haeckel.

#### “WELL WORTH STUDYING”

Accounts of Haeckel’s pictures tend to cut so rapidly to the confrontation of 1874–1875 that one of the most remarkable features of the whole episode is lost with the intervening years: by 1874 the *Schöpfungsgeschichte* had become the highly contested Darwinist gospel of nature and Haeckel a lightning rod for controversy, but none of his embryological illustrations was yet a major issue. Here I explain the initial failure of Rütimeyer’s charges by moving step by step from anatomists’ and zoologists’ early divisions through the debate that took shape in reviewers’ reactions and Haeckel’s responses.

With a higher print run (1,500 copies), the Reimers solicited more reviews, and the second (1870) edition was noticed more than the first. Beginning to stand out from the flood of Darwin literature, the *Schöpfungsgeschichte* gained a prominent place in the new German Empire’s “culture of progress,” the optimistic, nationalist, anticlerical cultivation of science, especially in the booming newspaper and magazine industry, that stretched politically from left liberals to moderate conservatives. New editions appeared in quick succession in 1872 (1,500), 1873 (2,500), and 1874 (2,500), and the “unusual book-trade success” of a fairly heavy tome was cited as the “most eloquent” testimony to increasing public interest in science.<sup>46</sup>

<sup>45</sup> Lionel Gossman, *Basel in the Age of Burckhardt: A Study in Unseasonable Ideas* (Chicago: Univ. Chicago Press, 2000), p. 8. On the characteristics of the Basel scholar, including lack of interest in popularization, see E. His, *Basler Gelehrte des 19. Jahrhunderts* (cit. n. 40), pp. 408–417. Wilhelm His had deep roots in the city, though some held his grandfather’s role in founding the Helvetic Republic against his patrician family. See *ibid.*, pp. 218–229; and Eduard His, *Chronik der Familie Ochs genannt His* (Basel, 1943). Rütimeyer was made an honorary citizen only in 1867: Schmidt, “Ludwig Rütimeyer” (cit. n. 40), p. 221. His’s seventieth-birthday tributes and obituaries evidence Basellers’ approval of his stance. See, e.g., Rudolf Burckhardt, “Zum siebenzigsten Geburtstage von Wilhelm His,” *Correspondenz-Blatt für Schweizer Aerzte*, 1901, no. 13, 1–7, on pp. 3–4 (pagination of offprint); and Anon., “† Wilhelm His,” *Basler Nachrichten*, 3 May 1904. While Wilhelm His took on Haeckel, his brother, the silk-ribbon merchant and art connoisseur Eduard His-Heusler, contributed documents to authenticate one of two paintings attributed to a distant ancestor, Hans Holbein the Younger. See Daniel Burckhardt-Werthemann, “Eduard His-Heusler,” *Basler Jahrbuch*, 1907, pp. 112–159; and Oskar Bättschmann and Pascal Griener, *Hans Holbein d. J. Die Darmstädter Madonna: Original gegen Fälschung* (Frankfurt am Main: Fischer, 1998).

<sup>46</sup> M[oritz] W[agner], “Neueste Beiträge zu den Streitfragen der Entwicklungslehre (Fortsetzung),” *Allgemeine*

Haeckel revised and expanded the text for the second edition and would keep on adding illustrations and using new prefaces to respond to criticisms, provoke attacks, and keep the book in the news. Though he signed the preface in early May 1870, late enough to have answered Rüttimeyer and likely also His, he took on the more general charges of hyper-Darwinism and irreligion instead. The old plates had to be redone, probably simply because the stones had not been kept. Haeckel removed the racial heads from the frontispiece—he had never been happy with the lithographer’s work—and another artist revised and doubled the gallery for an engraving inside the book. But the low-circulation objections of the Basel professors did not stop Haeckel from having (probably) the Giltches use the same originals for the embryo plates. These were even expanded to include the earlier stages of turtle and chick and given the definitive arrangement (see Figure 8 and the discussion above). The lone concession responded silently to Rüttimeyer’s only incontestable charge. Haeckel now labeled a single figure “the human egg” but noted that it “could just as well stem from . . . any other mammal”; the same block was used earlier in the book for the “egg of a mammal.” Similarly, though he still claimed that early embryos of reptiles, birds, and mammals were indistinguishable, he now labeled just one woodcut “embryo of a mammal or bird.”<sup>47</sup>

The *Schöpfungsgeschichte* began to make the similarity of early vertebrate embryos common knowledge. In *Das Ausland*, the magazine of ethnography, geography, and natural science that under Friedrich von Hellwald became a chief organ of Darwinism in Germany, a long review noted the “powerful support” that the theory of descent received from the fact that human and dog embryos were so “shockingly similar.” The embryological plates earned praise, even from critics abroad. In *Nature* Michael Foster, who lectured on chick embryology at Cambridge and inspired Britain’s first important embryological school, regretted that “the heads of men and monkeys, . . . at once absurdly horrible and theatrically grotesque, without any redeeming feature either artistic or scientific[,] . . . have been increased from twelve to twenty-four, but their quality remains the same.” Yet he lauded some “really beautiful and very instructive plates” of the development of various animals and “a large comparative view, well worth studying, of the embryos of the four vertebrate classes at two different epochs of their development” (Figure 8).<sup>48</sup>

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*Zeitung*, 3 Apr. 1873, no. 93B, pp. 1406–1408, on p. 1408. For the print runs see G. Reimer to Haeckel, 3 Nov. 1869 (2nd ed., more review copies), 7 Jan. 1874 (5th ed.), and E. Reimer to Haeckel, 1 Nov. 1871 (3rd ed.), 8 Jan. 1873 (Reimer wrote “1872”; 4th ed.), EHH. For the culture of progress see David Blackburn, *The Fontana History of Germany, 1780–1918: The Long Nineteenth Century* (London: Fontana, 1997), pp. 270–283.

<sup>47</sup> Ernst Haeckel, *Natürliche Schöpfungsgeschichte: Gemeinverständliche wissenschaftliche Vorträge über die Entwicklungslehre im Allgemeinen und diejenige von Darwin, Goethe und Lamarck im Besonderen, über die Anwendung derselben auf den Ursprung des Menschen und andere damit zusammenhängende Grundfragen der Naturwissenschaft*, 2nd ed. (Berlin: Reimer, 1870), pp. xxi–xxx, 170, 264–265, 271. On the waves of controversy stoked by new editions see Julius Sponholz, “Häckel und seine Gegner,” *Allg. Z.*, 21 Oct. 1875, no. 294B, pp. 4601–4602. For Haeckel’s criticism of the lithographer see E. Haeckel to A. Haeckel, 31 Aug. 1868, in *Ernst und Agnes Haeckel*, ed. Huschke (cit. n. 22), p. 49; and E. Haeckel to Huxley, 20 Oct. 1868, in Uschmann and Jahn, eds., “Der Briefwechsel zwischen Thomas Henry Huxley und Ernst Haeckel” (cit. n. 15), p. 19. But Haeckel rebutted the sympathetic Charles Lyell’s widely shared criticism that the Australian, African, and Tasmanian were drawn “too ‘*pithecoïd*.’” In older travel books, Haeckel claimed, “one often finds *even more* apelike faces”: Haeckel to Charles Lyell, 27 Nov. 1868, Edinburgh University Library, Lyell Correspondence, 1798.

<sup>48</sup> Anon., “Ernst Haeckels natürliche Schöpfungsgeschichte, 1: Die Abstammungslehre,” *Das Ausland*, 1870, 43:673–679, on p. 678; and M.F., “Haeckel’s Natural History of Creation,” *Nature*, 1870, 3:102–103. On Hellwald, a former Austrian officer and war ministry official and increasingly prominent apologist for the “right of the stronger,” see Bayertz, “Darwinismus als Politik” (cit. n. 8), pp. 244–246. Michael Foster—the *Nature* review’s only likely author—is a still more telling witness because he was just back from a German tour, during which he had “a very pleasant interview” with Haeckel and “a long chat with His and saw many of his preparations and photographs”; see Alan H. Sykes, *Sharpey’s Fibres: The Life of William Sharpey, the Father of Modern Physiology in England* (York: Sessions, 2001), pp. 151–152.

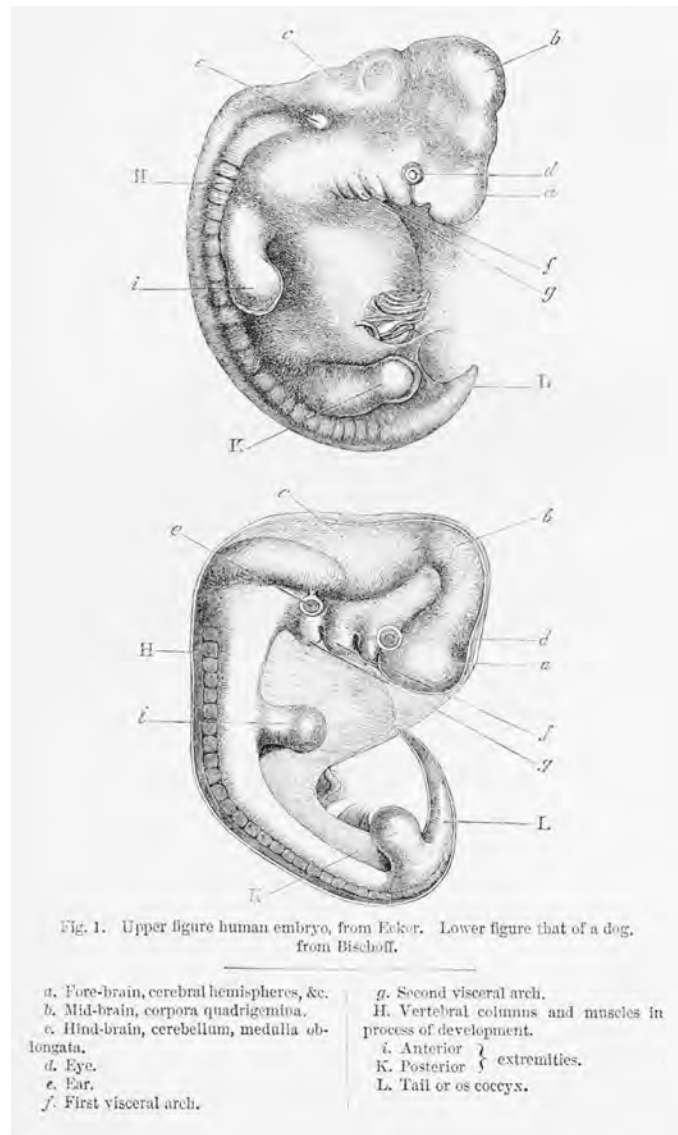


This approval chimed with the vindication Haeckel received in 1871 from the most important Darwinian event in years. *The Descent of Man* acknowledged the *Schöpfungsgeschichte* in the most flattering terms: “If this work had appeared before my essay had been written,” Darwin wrote, “I should probably never have completed it.” Haeckel celebrated his “greatest scientific triumph,” while others saw him as leading Darwin astray. Having brushed up on embryology and borrowed Bischoff’s and Ecker’s books from Huxley, Darwin used a full-page embryo pair as his first figure (Figure 10). “As some of my readers may never have seen a drawing of an embryo, I have given one of man and another of a dog, at about the same early stage of development.” Noting that Haeckel had given “analogous drawings,” Darwin stressed how “carefully” his own had been “copied from two works of undoubted accuracy” and recorded magnifications and the omission of “internal viscera” and “uterine appendages.” He may have been distancing himself from Haeckel’s practice, but the more important effect was to confirm great similarity. “What,” Haeckel asked, “will Mr Rüttimeyer [have to say], the left half of whose brain is Darwinist, and the right one (along with the entire choroid plexus) orthodox-clerical?”<sup>49</sup>

The following year the *Schöpfungsgeschichte* went into a third, lightly revised edition. Capitulating to the continued attacks, Haeckel removed the “ape plate,” even though it had been the selling point highbrow scientists feared, but kept the embryos, which had won new praise. With the book selling well, Wilhelm F. A. Grohmann of Berlin redid the plates as copper engravings. These were sharper and finer than the lithographs, though of lower contrast; the shapes remained the same, and with repeated steel facing the plates lasted until the eighth (1889) edition. Emboldened by Darwin, Haeckel now took on his Basel critics, mocking Rüttimeyer and travestying his attack as denying “the formal identity of the eggs and the young embryos of humans and the most closely related mammals,” when the point had been to denounce the means by which Haeckel had achieved it. He quoted Huxley, and then—perhaps reminded by the *Ausland* reviewer—wheeled out von Baer’s story of the unlabeled embryos. Wilhelm His served to illustrate the “astonishing misunderstanding” of a specialist who had “pursued ontogenetic investigations with great diligence (if also unfortunately without morphological judgment).” He had set up a “supposedly ‘mechanical’ theory . . . which every zoologist of clear judgment and knowledge of the facts of *comparative anatomy and ontogeny* can regard only with a smile.” Morphologists were indeed lukewarm toward His’s views, but he had more powerful backers: the physiologist Ludwig had just had him called to a chair at Jena’s larger rival, the University of Leipzig. Haeckel was also confirmed in his stance when Darwin wrote that he was “particularly glad to hear . . . your criticisms.” He had been “grieved” to read Rüttimeyer’s review: “I am sorry that he is so retrograde, as I feel much respect for him.” A reply to Haeckel was beneath Rüttimeyer’s dignity, and for the moment His kept his own counsel too.<sup>50</sup>

<sup>49</sup> Haeckel to Darwin, 24 Feb. 1871, Cambridge University Library, MSS.DAR.166:55 (and for “triumph”); and Charles Darwin, *The Descent of Man, and Selection in Relation to Sex*, 2 vols. (London: Murray, 1871), Vol. 1, pp. 4, 14–16. On Huxley’s and Darwin’s illustrations see Robert J. Richards, *The Meaning of Evolution: The Morphological Construction and Ideological Reconstruction of Darwin’s Theory* (Chicago: Univ. Chicago Press, 1992), pp. 158–164. For Darwin’s borrowing from Huxley see Darwin to Huxley, 20 June [1870], Imperial College London, Library, Archives and Special Collections, Huxley Papers, 5.269.

<sup>50</sup> Ernst Haeckel, *Natürliche Schöpfungsgeschichte: Gemeinverständliche wissenschaftliche Vorträge über die Entwicklungslehre im Allgemeinen und diejenige von Darwin, Goethe und Lamarck im Besonderen*, 3rd ed. (Berlin: Reimer, 1872), pp. xxxiii–xxxvi; and Darwin to Haeckel, 2 Sept. 1872, EHH. On His see Hopwood, “Giving Body” to Embryos” (cit. n. 43), pp. 468–469, 473–475. Regarding the steel facing see E. Reimer to Haeckel, 1 Feb. 1873, 13 Dec. 1888, EHH. They agreed not to reinstate “the ape plate” in the fourth edition in case this push “many pedantic owners of the 3rd” to ask for one too: E. Reimer to Haeckel, 1 Feb. 1873, EHH. The ninth (1898) edition carries a new double embryo plate showing six mammals at three stages.



**Figure 10.** Wood engravings of human and dog embryos from Charles Darwin, *The Descent of Man, and Selection in Relation to Sex*, 2 volumes (London: Murray, 1871), Volume 1, figure 1 on page 15. Compare Figure 2, B and E (the figures Darwin had copied), Figure 3, A and C (other wood engravings after Bischoff), and Figure 4, A–B (Haeckel's dog and human embryos), in this essay. Whipple Library, Cambridge.

The frontispiece to the fifth (1874) edition again showed a head, only now a single engraving depicting Haeckel himself (Figure 11). His own idea, the portrait responded to strangers' requests and to a "terrifying counterfeit [*Konterfey*]" that had appeared in *Die Gartenlaube*, the successful family magazine. Understanding the embryo plates as representing types, Haeckel shrugged off specialist objections that the figures differed from any specific originals. But scientific authorship was individual, and a portrait expected to cap-



**Figure 11.** Haeckel's first author portrait, the frontispiece to the fifth edition of his *Natürliche Schöpfungsgeschichte* (Berlin: Reimer, 1874). The Reimers paid the famous August Andorff of Berlin 120 marks—equal to one-tenth of the author's honorarium—for this copper engraving, but they had to admit that, though one round of revision got a good enough likeness, the work was hardly up to his earlier standard; he had become, "to put it mildly, very thirsty": Georg Reimer to Ernst Haeckel, 26 August 1874, Ernst-Haeckel-Haus, Jena. Universitätsbibliothek Tübingen.

ture in a likeness the character known to his family and now central to German Darwinism. A biography in the mass-circulation *Illustrirte Zeitung* began: "Haeckel's name gains more in popularity every day. Even the less educated person knows . . . at least . . . that he occupies a chair in Jena and has written a book that bears the title *Natürliche Schöpfungsgeschichte*." The biographer, the newspaper editor Otto Zacharias, had to acknowledge Haeckel's "legion of adversaries." In the Augsburg *Allgemeine Zeitung*, Germany's national newspaper and an influential forum for Darwinist debate, Haeckel was described as "a dogmatist of the worst sort," a latter-day *Naturphilosoph* who would take whatever stone fitted his edifice without checking it too carefully first. The critic was the "Old" Catholic theologian Johannes Huber, one of those who had broken with Rome over papal

infallibility and, like many scientists, would not accept an equivalent doctrine in science. The Berlin anthropologist Adolf Bastian, whom Haeckel had singled out for his favorite insult—that people opposed evolution because they had not evolved far enough themselves—accused “the fanatical crusade-preacher of a new faith” of throwing immature products out into the rough and tumble of the marketplace, where, “misinterpreted and misunderstood,” they “will degenerate into malformations.” The public had a right to protection from such “forgeries [*Fälschungen*]” as “on the plate of racial heads.” But Zacharias still insisted: “Haeckel is man enough not to let himself be diverted in any way from the path he has taken. He is not only an eminent scholar, but also a scientific character, a man of moral courage and of uncompromising single-mindedness.”<sup>51</sup>

Especially after Haeckel’s combative announcement of a highly speculative common ancestor of all multicellular animals, many zoologists criticized his disregard for their values of skeptical empiricism, intellectual openness, and modesty. His speculation and dogmatism harked back to the Romantic era and ironically (and iconically) mirrored the religion he attacked. Worries about illustrations were part of this larger alarm, but shared interests tempered concern. Zoologists’ best recruiting officer, Haeckel had stuck his neck out to defend morphology and promote Darwinism, which in some form the majority already accepted. As the newly independent discipline’s most famous *Ordinarius* he was harder to ignore than the materialists, but a professor who publicly opposed him risked common causes as well as his own honor. An attack would fan the flames and allow greater enemies, including laypeople, to exploit divisions. Was it worth the risk—over illustrations that could easily be seen merely to exaggerate into identity a point about similarity that was not in dispute?<sup>52</sup>

So in autumn 1874, on the eve of the publication of Haeckel’s second set of “popular scientific lectures,” fierce arguments over his character already raged. But though the illicitly repeated woodcuts had had to be removed from the *Schöpfungsgeschichte*, these were not yet much of a public issue and he was not under enough pressure to alter other embryological illustrations. Close colleagues and distant supporters found nothing wrong, opponents hated so much else that their views could be dismissed, and those in the middle kept their heads down. How, then, did the charges take off?

#### “HEAVY ARTILLERY IN THE ‘STRUGGLE FOR TRUTH’”

With the *Anthropogenie*, Haeckel made embryology the next great battleground over Darwinism and aligned the science’s major disciplinary conflict with the *Kulturkampf*, the “struggle of civilizations” that Bismarck was fighting against the Catholic Church. Before *Die Welträthsel* (“The Riddles of the Universe,” 1899), Haeckel’s “generally intelligible” books, especially this one, were too hard and the runs too low to count as bestsellers. Thanks to the publicity generated by reviews in newspapers and magazines, they never-

<sup>51</sup> Otto Zacharias, “Ernst Heinrich Häckel,” *Illus. Z.*, 1874, 63:235–238; Johannes Huber, “Wissenschaftliche Tagesfragen. I: Darwins Wandlungen und Häckels ‘natürliche Schöpfungsgeschichte,’” *Allg. Z.*, 8 June 1874, no. 159, pp. 2465–2466 (quotation), 10 June 1874, no. 161B, pp. 2498–2499; Haeckel, *Natürliche Schöpfungsgeschichte*, 3rd ed., p. xxxvii (insulting Bastian); and Adolf Bastian, *Offener Brief an Herrn Professor Dr. E. Häckel, Verfasser der “Natürlichen Schöpfungsgeschichte”* (Berlin: Wiegandt, Hempel & Parey, 1874), pp. 8–9, 24. The reasons for including the portrait are in Haeckel to G. Reimer, 13 Jan. 1873, SBB.

<sup>52</sup> For zoologists’ unease see Nyhart, *Biology Takes Form* (cit. n. 15), pp. 168–206. For praise for Haeckel’s support for morphology see, e.g., Siebold to Haeckel, 30 Oct. 1874, EHH. For reservations about going public see Carl Vogt, “Apostel-, Propheten- und Orakelthum in der Wissenschaft, I,” *Frankfurter Zeitung*, 15 Mar. 1877, no. 74, Morgenblatt, pp. 1–3, on p. 2.



theless played a crucial role in mediating between the concerns of the academic audience Haeckel was attempting to win for evolutionary morphology and the wider culture of progress. Some scientists, including his closest ally, Gegenbaur, concentrated on securing appointments and cultivating new fields of research; he trained an important comparative anatomical school, and he and His started rival journals. But Haeckel pressured his opponents, and gave them the chance, to engage more publicly. So hostile scientists were goaded into denouncing his embryological illustrations in ways that lay critics could pick up.<sup>53</sup>

The *Anthropogenie* was a simplified embryology textbook—not the most gripping genre—dedicated to the mutual illumination of ontogeny and phylogeny and “sexed up”—not with sex but with politics. Presenting the science as a secret kept by priestlike specialists gave the dull and difficult material the allure of forbidden knowledge.

If, even today, we say that every human individual develops from a simple egg, most so-called “educated people” reply only with an incredulous smile; and if we show them the series of embryonic forms that arise from this human egg their doubt as a rule changes into defensive disgust. Most of the “educated” have no suspicion at all that these human embryos conceal a greater wealth of the most important truths and form a more abundant source of knowledge than is afforded by the whole mass of most other sciences and all so-called “revelations” put together.

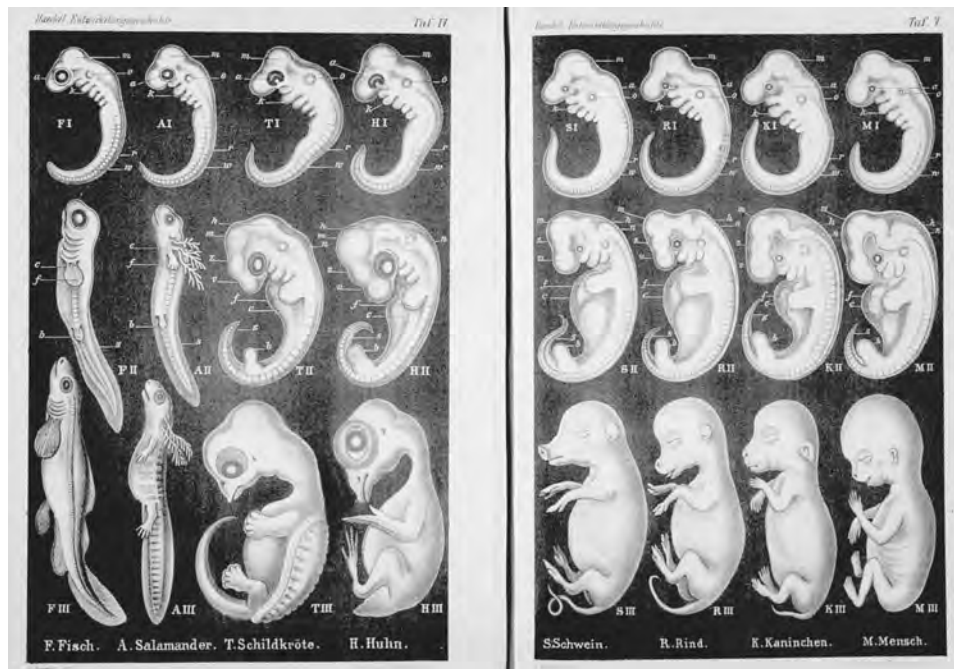
Making embryos decisive evidence for a worldview, Haeckel politicized a standard medical complaint about ignorance. The resigned “We shall never know” of the physiologist du Bois-Reymond played into the hands of the “black,” or Roman Catholic, “international.” Virchow had coined the term “*Kulturkampf*,” and other liberals followed Bismarck in this campaign of state anti-Catholic discrimination that in the mid 1870s entered its most repressive phase. Church property was seized and the army clashed with resisting crowds; Haeckel enjoyed seeing bishops and Jesuits in prison or exile. And in his holy war between “intellectual freedom and truth, reason and culture, development and progress,” on one side, and “intellectual servitude and falsehood, unreason and barbarism, superstition and retrogression,” on the other, “embryology [*Entwicklungsgeschichte*] is the *heavy artillery in the ‘struggle for truth.’*” The attempts of the “church militant” to damn “the naked *facts* of human *germ history*” as ““diabolical inventions of materialism”” best testified to ontogeny’s power.<sup>54</sup>

Illustrations were so crucial that Haeckel shifted to the leading zoological publisher and friend of the Jena Darwinists, Wilhelm Engelmann of Leipzig, in order to borrow most of the 210 wood engravings from his textbooks, especially Kölliker’s.<sup>55</sup> Haeckel added a few originals and a dozen plates, including an uncompromising frontispiece on the development of the face and a double comparative embryological lithograph with a much enlarged

<sup>53</sup> For Gegenbaur’s candid perspective see Carl Gegenbaur to Haeckel, 15 Sept. 1874, 10 Jan. 1875, 5 Apr. 1875, 17 Apr. 1875, EHH. For general works as mediating between esoteric and exoteric circles see Fleck, *Genesis and Development of a Scientific Fact* (cit. n. 4), esp. p. 112.

<sup>54</sup> Haeckel, *Anthropogenie* (cit. n. 12), pp. xi–xvi. On the *Kulturkampf* see Blackbourn, *Fontana History of Germany, 1780–1918* (cit. n. 46), pp. 261–263, 296–302. On scientists’ roles see Keith M. Anderton, “The Limits of Science: A Social, Political, and Moral Agenda for Epistemology in Nineteenth-Century Germany” (Ph.D. diss., Harvard Univ., 1993); and Goschler, *Rudolf Virchow* (cit. n. 17), pp. 244–246.

<sup>55</sup> Haeckel to G. Reimer, 13 Jan. 1873, SBB. Engelmann also offered a higher honorarium than Reimer paid for the largest editions of the *Schöpfungsgeschichte*. On Engelmann see —r, “Deutsche Buchhändler, 12: Wilhelm Engelmann,” *Illus. Z.*, 1869, 52:347–348; and *Verlagsbuchhandlung Wilhelm Engelmann, 1811–1911: Jubiläumskatalog der Verlagsbuchhandlung Wilhelm Engelmann in Leipzig* (Leipzig: Engelmann, 1911).



**Figure 12.** “Comparison of the embryos” of various vertebrates “at three different stages of development.” This expanded double plate shows fish (F), salamander (A), turtle (T), chick (H), pig (S), cow (R), rabbit (K), and human (M) embryos at “very early” (I), “somewhat later” (II), and “still later” (III) stages. It was “meant to represent [versinnlichen] the more or less complete agreement, as regards the most important relations of form, between the embryo of man and the embryo of other vertebrates in early periods of individual development. This agreement is the more complete, the earlier the periods of development in which the embryos of man are compared with those of the other vertebrates. It is retained for longer, the more closely the corresponding mature animals are related in descent.” Lithograph by J. G. Bach of Leipzig after drawings by Haeckel from his *Anthropogenie* (Leipzig: Engelmann, 1874), Plates IV–V.

grid (Figure 12). Gegenbaur found the book “in plan and execution equally excellent.” Another professorial comrade, the anatomist Carl Hasse of Breslau (now Wrocław), told Haeckel: “The large number of schematic figures gave me real pleasure, all the more because I know from my own experience the high pedagogical value of similar ones drafted by me for my lectures.” But, aware that Haeckel had burnt his fingers before, Hasse and the sober, publicity-shunning Gegenbaur warned him privately about illustrations they saw as crude, inaccurate, needing labeling as schematic, or unnecessarily provocative. Writing from Heidelberg, where he had just taken over the anatomical institute, Gegenbaur told his “dearest friend, . . . I’ll talk to you about the woodcuts at our next meeting. For the 2nd edition you really must change a good many.” Haeckel sought further advice and would act on some of it, but Hasse and Gegenbaur mostly highlighted different figures and let pass several that critics would target, including the double embryo plate. What would cause trouble, and how much, was not decided until the public debate.<sup>56</sup>

<sup>56</sup> Hasse to Haeckel, 19 Oct. 1874 (concerns about the title page and Plate XI), EHH; and Gegenbaur to Haeckel, 10 Nov. 1874 (quotations), 4 Dec. 1874, EHH. “Fig. 41 is quite strange to me,” Gegenbaur wrote in

Publication was a big event, much larger than if the Reimers had accepted Haeckel's commercially naive plan to tack an extra volume on embryology onto the *Schöpfungsgeschichte*. Engelmann got an essentially unchanged second edition of the *Anthropogenie* under the press before the first was even out. This made a total run of 4,500—large for such a difficult work—and the liberal publicity machine amplified the message further. In the *Illustrierte Zeitung* Zacharias concluded that “if a person wishes to take a step towards self-knowledge, he must study comparative embryology.” The paper, which claimed that its wood engravings drove cultural progress, reproduced Haeckel's grids.<sup>57</sup> The book's lay reception was fraught, however, also among friends, mainly because, although it claimed to be generally intelligible, even physicians could find it hard going. Having planned himself to write a review for *Ausland*, Hellwald, a soldier turned editor, had to let Zacharias, a private tutor turned editor, do this one as well. A long, early, positive review in a Bremen newspaper admitted that, “numerous illustrations” notwithstanding, the book “still needs to be studied more than read.”<sup>58</sup>

Professors often misjudged audiences beyond the lecture hall, and Haeckel was constrained by his wish to be read by colleagues and students too. Seeing the book do better among scientists, he doubted that embryology would ever become popular. But while he regarded the science as inherently dry and hard, a review “from the lay perspective” in the *Allgemeine Zeitung* portrayed him as constructing ignorance by his own insistence on esoteric material and exclusive jargon; mimicking the Church in wanting ignorant recruits, Haeckel intoned a fashionable dogma that party members must parrot. As a way out, the reviewer suggested that less expert readers play hostile scientists off against him. After all, even the black arts of Darwinist propaganda could not entirely bury “specialist reservations about, objections to, and refutations of the infallibility of the pronouncements of the masters.”<sup>59</sup>

Enter His, whose work Haeckel had assigned to “the lowest level in the literature of embryology.” Struggling to promote the mechanical views buried in his chick monograph, His used Haeckel's success to press his case more widely. Letters to his physiologist nephew, published in early 1875 as *Unsere Körperform und das physiologische Problem ihrer Entstehung* (“The Form of Our Body and the Physiological Problem of Its Genesis”), are a finely wrought dagger beside Haeckel's makeshift blunderbuss, visually unified—

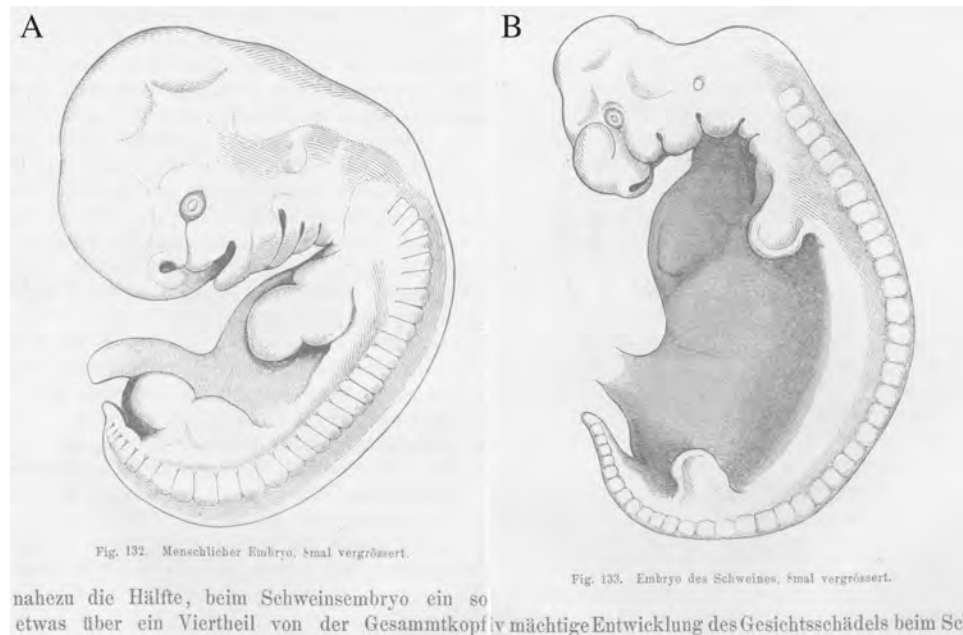
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the second letter—surely meaning to refer to figure 42 (which is original, while figure 41 is from Kölliker)—“and is presumably supposed to be only a schema, but you have not indicated this, so that readers could believe it be observed. In addition the woodcut looks very crude. Fig. 83 presents the brain shaped like a Liebig five-bulb apparatus and a mammalian brain *never* looks like that.” Gegenbaur also queried figure 122 and the general crudity of the new wood engravings compared to those from Kölliker. It was too late to act on this advice for the second edition, but Haeckel took some account of it for the third. His objected to figures 42 and 83, among others, but picked on a different aspect of figure 83.

<sup>57</sup> Otto Zacharias, “Ernst Häckel's ‘Anthropogenie,’” *Illus. Z.*, 1875, 64:42, 68–69, 119, 140–142; on the significance of wood engravings see “Vorwort,” *Illus. Z.*, 1875, 64:iii–iv. For Haeckel's plan see Haeckel to E. Reimer, 3 Jan. 1873, SBB; and E. Reimer to Haeckel, 8 Jan. 1873 (he wrote “1872”), EHH. For the run see Wilhelm Engelmann to Haeckel, 4 Aug. 1874, EHH.

<sup>58</sup> For a physician's difficulty see [Hinrich] N[itsch]e, rev. of Haeckel, *Anthropogenie*, *Literarisches Centralblatt*, 1875, no. 40, cols. 1291–1293; and for Hellwald's see Friedrich von Hellwald to Haeckel, 13 Oct. 1874, EHH. The Bremen review is “Häckel's Entwicklungsgeschichte des Menschen,” *Weser-Zeitung*, 1874, nos. 9987 (quotations), 9989, 9995. On Zacharias see August Thienemann, “Otto Zacharias †: Ein Nachruf,” *Archiv für Hydrobiologie und Planktonkunde*, 1917, 11:i–xxiv.

<sup>59</sup> Haeckel to Hellwald, 7 Feb. 1875, EHH; Anon., “Ultradarwinismus und Dilettantismus: Aus der Laienperspective,” *Allg. Z.*, 15 Apr. 1875, no. 105B, pp. 1625–1626, 16 Apr. 1875, no. 106B, pp. 1643–1645 (the quotation is from p. 1644, where the reviewer pointed out that Vogt had already criticized Haeckel's evolutionary trees).



**Figure 13.** “The specific physiognomies of young embryos.” Wood engravings of (A) a human, and (B) a pig embryo, from Wilhelm His, *Unsere Körperform und das physiologische Problem ihrer Entstehung* (Leipzig: Vogel, 1874), figures 132–133 on pages 194–195.

since money was apparently no object—with 140 (100 different) specially commissioned woodcuts. His did not need any particular degree of difference between embryos any more than, as he pointed out, Haeckel needed identity. But, committed to exact description as the basis for all embryological work, His invited readers to look at Haeckel’s illustrations closely. He repeated and expanded Rütimeyer’s criticisms of the embryo figures in the *Schöpfungsgeschichte*, thus putting these into wider circulation, and complained about Haeckel’s treatment of his former colleague. Turning to the *Anthropogenie*, His maintained that those embryological illustrations not reprinted from unimpeachable sources were “in part highly unfaithful, in part nothing short of invented.” He singled out three woodcuts of early human embryos and the comparative plate (Figure 12). Though the disputed points were esoteric, His appealed to accessible criteria of fair play: Haeckel could not claim that his figures were “schematic” when the text used them as proof of similarity. His showed how illustrations for nonspecialists could be exact and clear (Figure 13). He explained that he had drawn these “specific physiognomies” with a prism and shaded others after wax models laboriously reconstructed from serial sections. He insisted that the “differential diagnosis of embryos” must proceed by measurement, for the moment of drawings on card, and would eventually distinguish individuals.<sup>60</sup>

<sup>60</sup> Haeckel, *Anthropogenie* (cit. n. 12), pp. 52 (quotation), 161, 627–629; His, *Unsere Körperform* (cit. n. 19), pp. 168–171, 193, 201; Hopwood, “‘Giving Body’ to Embryos” (cit. n. 43); and Hopwood, “Producing Development” (cit. n. 1). Richardson and Keuck, “Question of Intent” (cit. n. 2), point out that His presented stages too advanced to clinch his case against Haeckel; as far as I know, this objection was not raised in the 1870s. At the urging of his nephew, Fritz Miescher, His was already planning his letters in the spring and summer before



Working also to cultivate in young researchers appropriate attitudes toward research, His, a loyal citizen of Basel and professor at a competitor university, made an example of Haeckel. While his word games “fall to the criticism of any reasonable thinker,” his tricks with pictures “can be seen through only by the special expert” and were particularly irresponsible given “the influence that he is able to exert on wide circles.” His maintained a lofty tone but, amplifying Rüttimeyer’s comment about the researcher’s duty, hit hard.

I myself grew up in the belief that among all qualifications of a scientist reliability and unconditional respect for the factual truth is the only one that we cannot manage without. Even today I am of the opinion that with the loss of this one qualification all the others pale, however brilliant they may be. Thus let others honor in Mr. Haeckel the active and daring party leader, in my judgment he has through the manner in which he has led the struggle himself relinquished the right to count as an equal in the company of serious researchers.

His aimed both to inspire the next generation to explain development physiologically and to show the dangers of conjuring up a finished worldview out of a few principles. Teachers had to smooth over gaps in knowledge, but researchers should not. In the face of ever-receding goals they must rather learn “resignation,” a form of scientific devotion Haeckel could hardly use.<sup>61</sup>

Haeckel was finally forced to respond, but his polemical counterattack ignored the argument that he had used the illustrations as evidence and dealt with the denunciation as a side issue that His had despicably blown out of all proportion. The embryos His said he had “invented” were evolutionarily justified deductions, one of which a newly described human embryo even confirmed. Those His said he had copied tendentiously were schematics, such as von Baer had given and everyone used for teaching. “In all hand- and textbooks schematic figures . . . find the widest application, and when His accuses me as the most serious crime, that my schematic figures are *invented*, then this accusation applies to all of those in just the same way. *All schematic figures are invented as such*. . . . They all represent an ideal abstraction at the expense of the concrete facts which in the process are necessarily more or less distorted.” Haeckel admitted now and then going “too far” in the use of schematic figures and regretted that some of the wood engravings had turned out “quite badly.” But he insisted that from such “trivial” weaknesses nothing followed for his views.<sup>62</sup>

This satisfied Haeckel’s supporters. Though smaller, cheaper, more informal, and advertised as “an important work for owners of Haeckel’s *Anthropogenie*,” His’s only book for a general—but, he more realistically admitted, scientifically educated—audience was much less widely reviewed. Haeckel’s rebuttal saved his fans the trouble of seeking it out.

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the *Anthropogenie* appeared; see Wilhelm His to Antonie Miescher-His, 26 July 1874, Staatsarchiv Basel-Stadt: PA 633, Schublade 15. Without Haeckel’s book, however, His would have lacked some prominent targets and his would have had less impact. Later, welcoming Wilhelm Roux’s work as combining phylogenetic and mechanical approaches, His confessed that “it was perhaps undiplomatic of me that, for all my great respect for the [Darwinist] theory and its founder, . . . I took a stand against the uncritical approach of its prophet. I should have associated myself much more definitely with the general view than I did and arranged my particular endeavors within it. That cannot now be changed, and it has never especially troubled me to see myself ostracized by certain parties”: His to Paul Sarasin, 30 Oct. 1889, Staatsarchiv Basel-Stadt: PA 212 T2 118.

<sup>61</sup> His, *Unsere Körperform*, pp. 171, 214–215. Carl Vogt, “Wissenschaftliche und unwissenschaftliche Bückerei, IV,” *Frankfurt. Z.*, 31 Mar. 1875, no. 90, Morgenblatt, pp. 1–2, was reminded of battles between Leipzig and Jena fraternity students.

<sup>62</sup> Haeckel, *Ziele und Wege der heutigen Entwicklungsgeschichte* (cit. n. 23), pp. 36–39; on the new specimen and its fate at His’s hands see Hopwood, “Producing Development” (cit. n. 1).

In *Ausland* Zacharias deployed the spicy pamphlet against “His’s nonsense,” and in *Gartenlaube* the journalist Ernst Krause, alias Carus Sterne, dismissed His’s views. The school-teacher and botanist Hermann Müller thanked Haeckel for “the excellent analysis of the fundamental lack of clarity in the views of His.” Claiming to be the first to introduce the *Anthropogenie* into the school classroom, he enlarged the figures as “colored wall charts.” Friendly professors also welcomed Haeckel’s attack.<sup>63</sup>

His did not have anything like this publicity network and, as an embryologist oriented toward mechanistic physiology, still stood alone. But his intervention allowed skeptical reviewers to attack Haeckel more easily and safely by citing him. He likely encouraged the several specialists, including Bischoff, who now protested at Haeckel’s cavalier treatment of embryological illustrations they knew well, and the other main scientist-critic, the Würzburg professor of zoology and comparative anatomy Carl Semper. A one-time supporter, already disillusioned, Semper aimed in a public lecture “to make the general educated public aware of the errors and hypotheses on which *Haeckel’s teachings* are founded” in order to protect zoology from the threat to its freedom that his excesses risked bringing forth. Semper quoted His’s criticism of Haeckel’s “forgeries [*Fälschungen*].”<sup>64</sup>

Lay enemies now put His’s accusations to work for their own, often very different, ends. Here is an extreme example from deep behind enemy lines. In the dominantly orthodox Catholic milieu, where Haeckel’s influence appears to have become seriously worrying only in 1873–1874, His and Semper were used to disqualify him as a scientist. “Modern culture” was here damned “as the enemy of religion and the Church” and Darwinism, a new materialism, as fit only for the liberals’ shallow world of *Stammtisch* newspaper reading over beer and tobacco. Dr. Carl Scheidemacher, a priest who taught at the cathedral school in Aachen, paid His unusual attention as an authoritative witness to “*deliberate falsification* [*Verfälschung*]” by Haeckel, “a charlatan on the chair of a German university, who with his bragging combines the crudity of the gutter and the knavish dishonesty of the swindler.” For Scheidemacher, even Darwin’s argument from similarity proved nothing—since dog embryos produced only dogs, the significant differences must (as Darwin and Haeckel indeed accepted) simply be hidden—and so fraud was added to a charge sheet already longer than an orang’s arms.<sup>65</sup>

<sup>63</sup> The advertisement is in *Die Gegenwart*, 1875, 7:208; at 5M. 50Pf. *Unsere Körperform* was just over a third the price of the *Anthropogenie* (14M.; see, e.g., N[itsch]e, rev. of Haeckel, *Anthropogenie* [cit. n. 58]). For the responses see Otto Zacharias, “Ziele und Wege der heutigen Entwicklungsgeschichte,” *Ausland*, 1876, 49:29–32, on p. 30; Carus Sterne, “Menschliche Erbschaften aus dem Thierreiche,” *Die Gartenlaube*, 1875, 23:266–268, on p. 267; and Hermann Müller to Haeckel, 21 Nov. 1875, EHH. Müller’s use of Haeckel later figured prominently in a debate that led to a long-term restriction of school biology teaching; see Philipp Depdolla, “Hermann Müller-Lippstadt (1829–1883) und die Entwicklung des biologischen Unterrichts,” *Sudhoffs Archiv*, 1941, 34:261–334. For scientists’ support see Gegenbaur to Haeckel, 25 Nov. 1875, EHH; and Theodor W. Engelmann (a physiologist, the publisher’s son, and Haeckel’s former student) to Haeckel, 28 Dec. 1875, in *Deutsche Ärztebriefe des 19. Jahrhunderts*, ed. Manfred Stürzbecher (Göttingen: Musterschmidt, 1975), pp. 132–135. The Darwinist Ludwig Overzier studied His and still concluded that vertebrate embryos were almost identical: L. Overzier, “Ueber die Darwin-Häckel’sche Auffassung der organischen Natur,” *Gaea*, 1875, 11:357–363. On the response to His see further Hopwood, “‘Giving Body’ to Embryos” (cit. n. 43), pp. 473–475.

<sup>64</sup> Carl Semper, *Der Haeckelismus in der Zoologie: Ein Vortrag gehalten am 28. October 1875 im Verein für Kunst und Wissenschaft zu Hamburg, unter dem Titel “Der neue Glaube und die moderne Zoologie”* (Hamburg: Mauke’s Söhne, 1876), pp. 35–36 (“forgeries”); the other quotation is from an advertisement for this pamphlet in *Gegenwart*, 1 Jan. 1876, 9:16. On Semper see August Schuberg, “Carl Semper †,” in Semper, *Reisen im Archipel der Philippinen*, Pt. 2: *Wissenschaftliche Resultate*, suppl. (Wiesbaden: Kreidel, 1895), pp. vii–xxi; see also Semper’s “Kritische Gänge,” *Arbeiten aus dem Zoologisch-Zootomischen Institut in Würzburg*, 1874, 1:73–82, 208–238. For other scientists’ criticisms see Gursch, *Die Illustrationen Ernst Haeckels zur Abstammungs- und Entwicklungsgeschichte* (cit. n. 1), pp. 42–60.

<sup>65</sup> Carl Scheidemacher, “Ueber den Stand des Darwinismus, 10. Artikel: Kritik der Abstammung des

Such attacks could only confirm Haeckel in the rightness of his stand, and as long as scientific allies judged his defense successful he would not give any ground. He revised a few of the disputed figures for the third (1877) edition of the *Anthropogenie*, repeated his points about schematics and deductions, and let the comparative embryological plates stand. Fraud stopped being news, not because anyone was won over, but because other events eclipsed it. Haeckel, like a bull in the china shop where scientific leaders were trying to work out a relationship with the Prusso-German state, kept inciting new controversies that distracted attention from the old ones. So it is hard to assess the weight of the forgery charges in damaging his reputation; for many, some 1876 speculations over cellular memory were the last straw. In 1877 Virchow, himself cautious toward evolution, challenged Haeckel by insisting that science would be endangered if mere hypotheses were taught in school. At the same time, a major national shift to the right threw Darwinists onto the defensive against fears of socialism, such as Virchow also raised. With no new editions fueling controversy, the debate over Haeckel's pictures died down in the 1880s, though without achieving closure: it is a myth that he was tried and convicted of fraud. Different milieux sustained different views.<sup>66</sup>

Specialist work greatly enriched comparative vertebrate embryology, giving Haeckel material with which to expand his illustrations but also challenging their framework deeply. In the early 1880s His reformed human embryology; the embryo Haeckel had used against him was reclassified as that of a bird and excluded from the "normal plate" with which he founded a more specialist field. On this model from 1897 the anatomist Franz Keibel edited *Normal Plates of the Vertebrates*, which effectively turned each of the columns in Haeckel's comparative plates into a complex monograph. Keibel was interested in the temporal displacements that prevented specialists from lining up embryos at the common stages implied by Haeckel's rows. Streamlined versions serve as "normal stages," labo-

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Menschen," *Periodische Blätter zur Wissenschaftlichen Besprechung der Großen Religiösen Fragen der Gegenwart*, 1874, 3:362–371, on pp. 369–370 (critique of Darwin's similarity argument); Scheidemacher, "Häckels Ziele und Wege der heutigen Entwicklungsgeschichte," *ibid.*, 1876, 5:38–48 (quotations from pp. 44, 48); Scheidemacher, "Neue Beiträge zum Häckel'schen Schwindel in der sogen. Culturwissenschaft mit Randglossen," *ibid.*, pp. 135–142 (Semper); and Scheidemacher, "Ueber das Schicksal E. Haeckels vor dem Forum der fachgenössischen Wissenschaft," *Natur und Offenbarung*, 1876, 22:646–655, 705–714. The *Periodische Blätter* had a regular section on "Moderne Cultur als Feindin von Religion und Kirche." On the Catholic reception of Darwinism see Hermann Josef Dörpinghaus, "Darwins Theorie und der deutsche Vulgärmaterialismus im Urteil deutscher katholischer Zeitschriften zwischen 1854 und 1914" (D.Phil. diss., Albert-Ludwigs-Universität Freiburg im Breisgau, 1969), esp. pp. 43–48; for liberal newspaper readers viewed from the Catholic milieu see August Reichensperger, *Phrasen und Schlagwörter: Ein Noth- und Hilfsbüchlein für Zeitungsleser*, 3rd ed. (Paderborn: Schöningh, 1872). The Protestant botanist Albert Wigand, an influential critic, also used His's charges against Haeckel; see Wigand, *Der Darwinismus, ein Zeichen der Zeit* (Heilbronn: Gebr. Henninger, 1878), p. 49.

<sup>66</sup> Revisions in the third edition include suppression of figure 42, improvement of figure 83, and partial re-drawing of Plate XI; see Ernst Haeckel, *Anthropogenie oder Entwicklungsgeschichte des Menschen: Gemeinverständliche wissenschaftliche Vorträge über die Grundzüge der menschlichen Keimes- und Stammes-Geschichte*, 3rd ed. (Leipzig: Engelmann, 1877), pp. 240, 304, and Plate XIV. The conviction story, much repeated in the recent controversy, could have its source in a misunderstanding of either Haeckel's invocations of imaginary trials—see, e.g., "Apologetisches Schlusswort" (cit. n. 25), p. 858—or the 1893 libel case involving a disgruntled former student, Otto Hamann, who abandoned Darwinism and used the Rütimyer/His charges against Haeckel; both were fined, but Hamann much more. See Gursch, *Die Illustrationen Ernst Haeckels zur Abstammungs- und Entwicklungsgeschichte* (cit. n. 1), pp. 69–72. On other controversies, especially with Virchow, see Dietrich von Engelhardt, "Polemik und Kontroversen um Haeckel," *Medizinhistorisches Journal*, 1980, 15:284–304; Jutta Kolkenbrock-Netz, "Wissenschaft als nationaler Mythos: Anmerkungen zur Haeckel-Virchow-Kontroverse auf der 50. Jahresversammlung deutscher Naturforscher und Ärzte in München (1877)," in *Nationale Mythen und Symbole in der zweiten Hälfte des 19. Jahrhunderts*, ed. Jürgen Link and Wulf Wülfing (Stuttgart: Klett-Cotta, 1991), pp. 212–236; and Bayertz, "Darwinismus als Politik" (cit. n. 8), pp. 253–265.

ratory standards in developmental biology today. Other biologists went beyond His's analytical mechanics as they recast embryology as an experimental science.<sup>67</sup>

Meanwhile, by continuing to exploit the forgery charges, Haeckel's religious and scientific enemies, most prominently Hensen, forced him into an "Apologetic Afterword" to the fourth (1891) edition of the *Anthropogenie*. Haeckel developed his old lines of defense and excused himself, without really apologizing, for "the story of the three clichés." But discussion remained at a low level until, in the early twentieth century, the ideological struggle intensified, now especially for working-class readers, between freethinkers, in Haeckel's Monist League, and their right-wing Protestant rivals, in the Kepler League. In 1908 an antievolutionist Kepler League lecturer, Arnold Brass, accused Haeckel at a meeting of the anti-Semitic Christian Social Party of new forgeries in the published versions of major public lectures, and the league's publicity machine made the story big news. No research agenda was now at stake, but anatomists and zoologists, almost all of them committed to evolution, felt the threat of outside interference. A narrow majority of the imperial German full professors rallied round, lightly reproving Haeckel but censuring Brass and the Kepler League. Biologists remained divided, however, and Christian enemies continued to cast Haeckel as a forger.<sup>68</sup>

Though specialist visual standards were in part a reaction against Haeckel's pictures, authoritative publications have accommodated both. Copied at first only into general biological books, not embryology texts other than new editions of the *Anthropogenie*, his comparative plates were eventually reproduced, sometimes redrawn more accurately, in works that kept comparative embryology alive after his program collapsed following World War I. Turning their backs on everything Haeckel represented, neither His-inspired human embryology nor developmental biology—from the 1960s experimental embryology's successor—cared much about comparing vertebrate embryos. They also failed to cultivate a memory of the controversies over illustrations that were nevertheless reproduced. Stephen Jay Gould's *Ontogeny and Phylogeny* (1977) did a great deal to rehabilitate Haeckelian topics and, significantly for a scientist sensitive to the power of evolutionary icons, avoided the pictures.<sup>69</sup> Historians of embryology treated image making as incidental, and specialist work on the controversies was too little known. The latest row broke out because in 1997 the new interest in evolution brought developmental biologists to look more closely at the illustrations that littered their textbooks like so much unexploded ordnance in the fields after a forgotten war. Creationists made sure it inflicted maximum damage when it went off. The lesson is not simply that those who cannot remember the past are condemned to repeat it.<sup>70</sup> To do justice to Haeckel's embryos, historical reflection needs to take seriously

<sup>67</sup> Hopwood, "Visual Standards and Disciplinary Change" (cit. n. 7); and Nyhart, *Biology Takes Form* (cit. n. 15), pp. 278–305.

<sup>68</sup> Haeckel, "Apologetisches Schlusswort" (cit. n. 25), pp. 861–862; Assmuth and Hull, *Haeckel's Frauds and Forgeries* (cit. n. 1); Gursch, *Die Illustrationen Ernst Haeckels zur Abstammungs- und Entwicklungsgeschichte* (cit. n. 1), pp. 84–136; and Daum, *Wissenschaftspopularisierung im 19. Jahrhundert* (cit. n. 4), pp. 210–235. The majority emerges from analysis of the signatories of a 1909 declaration, for which see Schmidt, *Haeckels Embryonenbilder* (cit. n. 1), pp. 50–51.

<sup>69</sup> Gould, *Ontogeny and Phylogeny* (cit. n. 15), refers to and quotes from His's accusation only in n. 22, on p. 430. Reproductions include George John Romanes, *Darwin and after Darwin: An Exposition of the Darwinian Theory and a Discussion of Post-Darwinian Questions*, 3 vols., Vol. 1: *The Darwinian Theory* (London: Longmans, Green, 1892), pp. 152–153, an especially important source for twentieth-century textbooks; Theodore W. Torrey, *Morphogenesis of the Vertebrates* (New York: Wiley, 1962), title page and p. 9 (redrawn); and Harold W. Manner, *Elements of Comparative Vertebrate Embryology* (New York: Macmillan, 1964), p. 7. For further examples see Rusch, "'Ontogeny Recapitulates Phylogeny'" (cit. n. 1), p. 34; and Richardson and Keuck, "Haeckel's ABC of Evolution and Development" (cit. n. 1), pp. 515, 518–519.

<sup>70</sup> Gould, "Abscheulich!" (cit. n. 1), p. 45.



how meanings are made as pictures move between classroom teaching, research programs, and public debate.

#### DISCUSSION

Reconstructing the production of Haeckel's pictures of vertebrate embryos and their interpretation by authoritative readers between 1868 and 1877 explains how they were made innovative, controversial, and influential. Faced with visual resources inadequate to his comparative ambitions and determined to make an esoteric science attractive, Haeckel combined figures of species types to create unprecedentedly vivid illustrations for his provocative text. The double-developmental grid was not imported ready-made but built up in several steps from pairs of drawings. Haeckel pushed the limits of acceptable practice, but only in the cases of the three clichés did he undoubtedly, indefensibly, and, for his argument, unnecessarily sin against the standards of his day. Anatomists and zoologists were divided: the most expert and hostile objected straightaway, but only one of them in public, while among those at his own broadly competent level some even voiced praise. Although he was soon immensely controversial, forgery did not become a big issue for several years.

Why was Haeckel accused—and of forgery and fraud rather than error? The failure to confirm the organic nature of Huxley's deep-sea slime, *Bathybius haeckelii*, was embarrassing, but its author's reputation was not dragged as far into the mud.<sup>71</sup> The reception of the *Schöpfungsgeschichte* gave Haeckel's contested character peculiar prominence in German Darwinism and ensured the presence of a host of enemies ready to exploit scientists' divisions. But though at least as tendentious, his evolutionary trees were not generally criticized as forgeries, only as excessively speculative and dogmatic. The repetition of the blocks would be widely used to discredit other pictures but does not seem to have had such a toxic effect in the first six years. In the later phases of intense controversy, too, in-print illustrations seem to have mattered more. Crucially, the trees were hypothetical, while the embryological illustrations (like the ape plate) claimed to communicate established facts that competent scientists could judge from readily available sources. For Haeckel, the figures merely illustrated views he had arrived at by other means, but his opponents saw him treat them as evidence—and tampering with visual evidence was widely understood as more heinous than any verbal sleight of hand. The Basel anatomists' attitudes and interests led them to raise the alarm, but Haeckel brought down trouble by intensifying the struggle for embryology and persisting with the same illustrative practices just as concern mounted over his approach. A dispute among scientists, in which the most prominent critics were committed to evolution and saw Haeckel's pictures as irrelevant to its validity, thus created the opportunity for a controversy that would be fought out most noisily between Darwinist freethinkers and their religious opponents.

The positions of supporters and critics of Haeckel's illustrations can be explained in terms of their competence and politics—disciplinary and religious, national and local. Cheered in the culture of progress and damned in the seminaries, his speculative scientism annoyed scientific leaders pushing for limits on research, or at least teaching, in exchange for autonomy within them. Can we also map divergent stances toward image making itself?

<sup>71</sup> Philip F. Rehbock, "Huxley, Haeckel, and the Oceanographers: The Case of *Bathybius haeckelii*," *Isis*, 1975, 66:504–533. See Charles F. O'Brien, "*Eozoön Canadense*: 'The Dawn Animal of Canada,'" *ibid.*, 1970, 61:206–223, on pp. 215–216, for an accusation of the deliberate use of inaccurate figures.

From the mid-nineteenth century, Lorraine Daston and Peter Galison have argued, an ideal of truth to nature, in which interference was permitted in order to represent types, was challenged by a “mechanical objectivity” in which scientists, seeking to discipline a newly unruly subjectivity, preached self-restraint and dared to depict only individuals. The His–Haeckel confrontation can then be interpreted as making this larger shift in regimes of representation explicit. Reacting against the empiricism of the 1840s and 1850s, Haeckel certainly drew types; His deployed a moderate mechanical objectivity against him; and Haeckel’s riposte rejected this. But does the case also represent a general turning point in image-making practice? That in these very years His was promoting more complex and in part more mechanical methods of representing embryos certainly increased his own interest in challenging Haeckel, but though the critique used the new techniques it did not depend on them, any more than did those of Bischoff, Rüttimeyer, and Agassiz. Mechanical objectivity made little difference to morphology; full mental participation in drawing as a means to understanding remained too central well into the twentieth century. As the category of “schematic” makes clear, any one scientist also drew in several distinct ways for different purposes and audiences. The distinctions have yet to be reconstructed in any detail, but the routines of undergraduate pedagogy were surely especially resistant to mechanical objectivity. Around 1900 a few anatomist-embryologists were so committed to representing only individuals that they even rejected the notion of “stage.” But types, or characteristic individuals that stood for types, continued to dance through textbooks, across blackboards, and around display cases for decades to come.<sup>72</sup>

Transported to new contexts of viewing and converted into fresh material forms, Haeckel’s illustrations of vertebrate embryos remained in print to play a major role in promulgating embryological visions of pregnancy and the history of life on earth. The pictures survived into new editions because Haeckel could dismiss their critics as opposing Darwinism or even evolution, while other scientists either supported him or reckoned the cost of opposition too high. At first most viewing was of the illustrations in Haeckel’s books—often, critics worried, at the expense of the text. How, it would be worth exploring, did groups who did not author reviews interpret them, and were any links made to other embryo politics, such as the antiabortion law of 1871 (there are none in the responses I have cited here)? But since most reviews lacked illustrations and Darwinism was by no means generally acceptable even by 1914, in some circles the pictures will have remained more read about than seen.<sup>73</sup> Soon most encounters were with reproductions. The wood engravings in the *Illustrierte Zeitung* and copies in more popular evolutionary works circulated in larger numbers than the originals; how did new contexts and physical forms affect meanings? By the mid-twentieth century, biology textbooks had taken over as their main home. How did the pictures last so long, and what were the effects on this stability of the (very different) controversies in 1908–1910 and since 1997? How did these icons come to seem too striking, significant, or standard to hide, too inaccurate, risqué, or boring to show?

<sup>72</sup> Daston, “Objectivity versus Truth” (cit. n. 5), pp. 28–29; see also Daston and Galison, “Image of Objectivity” (cit. n. 5). Haeckel’s earlier praise for the camera lucida as producing “objective” plates with “almost mathematical exactitude” is compatible with a search for truth to nature, provided we are not too fussy about terms (whether or not his radiolaria are exact is another matter); see Ernst Haeckel, *Die Radiolarien* (Rhizopoda radiaria): *Eine Monographie* (Berlin: Reimer, 1862), p. xi. For the rejection of stages see Hopwood, “Visual Standards and Disciplinary Change” (cit. n. 7), pp. 253, 256–259.

<sup>73</sup> A successful spoof of the *Anthropogenie* could assume enough familiarity to base a visual gag on the frontispiece, which the *Illustrierte Zeitung* had not reproduced: Moritz Reymond, *Das neue Laienbrevier des Haeckelismus: Genesis oder die Entwicklung des Menschengeschlechts: Nach Häckel’s Anthropogenie in zierliche Reimlein gebracht* (Bern: Frobeen, 1877), pp. 25–26.

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.