Human embryonic gills and gill slits—down but not out

Jerry Bergman

A survey of recent biology textbooks and popular science literature shows that while most authors no longer use the idea that a human embryo develops 'gills' and 'gill slits', some still retain this false claim and others contain indirect references to it. Anatomical and histological studies clearly show that the folds of tissue in the neck region of human embryos (pharyngeal ridges) are not homologous with the gills that develop from the side of the head in fish embryos. The pharyngeal ridges in human embryos develop into a variety of different structures, none of which are respiratory organs.

Haeckel's Biogenetic Law

Darwinists once believed that as the human embryo developed, it passed through its major evolutionary stages. This theory, called the *biogenetic law* or the *embryonic recapitulation law* (or just the *recapitulation law*), stated that human life begins as a single cell similar to the first life forms, then develops into a fish stage, a reptile stage, a mammal stage, an ape stage and, before birth, ends up at the highest life form evolution has so far achieved, the human stage.[1,2] This concept is summarized in the expression 'ontogeny recapitulates phylogeny', which means that 'the development of the individual repeats the evolution of the race'.[3] One of the 'iconic' stages in this process was supposed to be the development of 'gills'—'The human embryo with gill depressions in the neck was believed … to signify a fishlike ancestor.'[4] This view was popularized by the German biologist Ernst Haeckel. He produced a set of drawings—later found to be grossly distorted—that have been reproduced in almost every biology textbook since the turn of the century.[5]

Darwin considered the embryological arguments to be 'second in importance to none' as support for his theory of evolution.[6] In his *Descent of Man*,[7] he devoted the entire first chapter to this line of evidence, stressing how critical it was to his theory. As a result the 'biogenetic law' has been a leading argument in support of Darwinism ever since.[8] Sir Julian Huxley, for example, championed the argument as follows:

> 'Embryology gives us the most striking proof of evolution. Many animals which are extremely different as adults are hard to tell apart as embryos. You yourself when you were a young embryo were very like the embryos of lizards, rabbits, chickens, dogfish, and other vertebrates. The only reasonable explanation is that we vertebrates are all related by common descent. … Even more extraordinary is the fact that we and all other land vertebrates show a fish-like plan of construction in early embryonic life, with a fish-like heart, gill-slits, and pattern of blood-vessels. This only makes sense if we, as well as all other mammals, birds and reptiles, have gradually evolved from some kind of fish.'[9]

A 1931 textbook noted that tadpoles have 'unquestionably fish-like characteristics' such as a functioning system of gills that gradually is absorbed and replaced by lungs as the tadpole develops into a frog. The text then claimed that similar examples are also

> ' … found in the course of human development. When the human embryo is a small fraction of an inch in length a definite number of narrow transverse clefts appear on its neck ... These clefts lead into the throat and correspond in position to the gill openings of fishes. ... These embryonic organs in man never serve for breathing as the corresponding parts do in fishes, but in gross structure the human gill arches recall in a most striking way

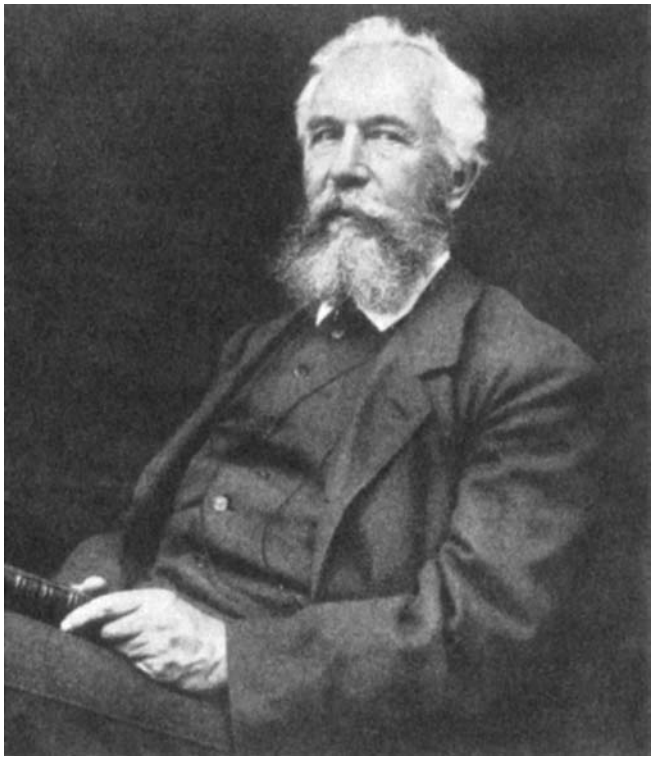

Figure 1. *Earnest Haeckel at sixty-two in*

the gill system of fishes. As the development of the human embryo proceeds, the gill clefts are obliterated, excepting the first one which is retained in forming the aperture of the external ear.'[10]

Another textbook stated that a one-month-old human embryo contained a set of:

' … paired bronchial grooves in the neck region. These are matched on the interior by a series of paired gill pouches. This pattern appears not only in man but in the embryonic development of all vertebrates. In the fishes, the pouches and grooves eventually meet and form gill slits, the openings which allow water to pass from the pharynx over the gills and out of the body. In the "higher" vertebrates the grooves and pouches disappear. In man the chief trace of their existence is the Eustachian tube and auditory canal, which (interrupted only by the eardrum) connect the pharynx with the outside of the head.'[11]

The idea even appeared in the world's best-selling child-care book by Dr Benjamin Spock. He stated that watching a baby grow is 'full of meaning' because the development of each individual child retraces

' … the whole history of the human race, physically and spiritually, step by step. Babies start off in the womb as a single tiny cell, just the way the first living thing appeared in the ocean. Weeks later, as they lie in the amniotic fluid in the womb, *they have gills like fish*. Toward the end of the first year of life, when they learn to clamber to their feet, they're celebrating that period millions of years ago when our ancestors got up off all fours' [emphasis mine].[12]

This theory, however, has now been fully refuted. As early as 1900 Haeckel's Biogenetic Law was shown to be a sweeping and superficial generalization, untenable in most particulars, and leading scientists eventually abandoned it.[13] Furthermore, Haeckel's drawings have long been known to be fraudulent.[14–20] Although by the end of the 1920s, Haeckel's theory had, in Gould's words, 'utterly collapsed'[21] it persisted in many textbooks as evidence for Darwinism.[8] Only recently have many textbook publishers agreed to correct this and other 'embarrassing errors'.[22]

The fable persists

Although Darwinists generally have dropped most of the historically accepted biogenetic stages, they sometimes claim that a few are retained and the most commonly cited example is the 'fish' stage. There appear to be two reasons for this. One is that the range of supposed evidences for evolution is dwindling, so they have to make the most of any and every possibility that remains. Mammals are thought to have evolved from sea creatures, so it 'logically follows' that their embryonic stage should have 'gill slits that resemble fish gills'.[23] In their enthusiasm to prove evolution some Darwinists have gone further and claimed that at one point the human embryo actually develops gills and resembles a tadpole.[8] The influential author Isaac Asimov claimed that gills in chordate embryos are 'developed as in fish and are [later] replaced by lungs', and that the embryo develops 'gills first and only thereafter lungs'.[24] This clearly shows how evolution can be driven by ideology rather than by science.

The second reason for the persistence of the gill icon is that the skin folds in early vertebrate embryos do look superficially similar. When you combine this superficial similarity with the fact that most textbook writers draw on the work of other textbook writers it is not hard to see how the idea can be passed on uncritically. Some argue that 'whether or not books talk about gill slits is simply a matter of "terminology" '.[22] Of course, correct terminology is critical in biology and this excuse is irresponsible. Another reason why the idea persists is because most textbook authors rely on the texts they used in college as a guide to write their own textbooks and, as a result, this and many other errors are repeated decade after decade. Few textbook authors are specialists in all of the areas that they include in their text and tend to rely on other texts for much of their material.

Changes in the textbooks

A survey of 45 recent college level biology textbooks revealed that most did not mention the gill-slit argument as evidence for evolution, whereas almost all of the pre-1950's books that discussed Darwinism did so. Unfortunately, a few post-1960 textbooks have continued to perpetuate the myth, even if only in diagrams.[25] One 1995 college text stated that fish, reptiles, birds, and humans all share 'gills and a tail' in their early development.[26] Another new college text claims that the 'early stages of embryonic development are almost identical in different vertebrate species. Numerous structural similarities are shared by the early stages, including the presence of gill pouches and a tail'.[27]

A Newton University educational program claims 'all mammals have gill slits in their very early fetal development', proving ontogeny recapitulates phylogeny.[28] Similarly, a Palomar College zoology class handout claimed that 'at some time in their life cycle, chordates have a pair of lateral gill slits or pouches used to obtain oxygen in a liquid environment. In the case of humans, other mammals, birds, and reptiles, lungs replace gill slits after the embryonic stage of development'.[29] Even respected journals like *American Scientist*—'embryos of all major groups of vertebrates do possess gill pouches and gill furrows, and these similarities clearly reveal Darwin's evolutionary principle of descent with modification from a common ancestor'.[30]

Some texts do not *directly* claim that the human embryo has gills or gill slits, but use wording that implies they do, such as the term 'gill pouches'.[31] Beck *et al*. claim that the

putative 'gill pouches' cause the embryo to be 'vaguely fish-like'[40] yet this text at the same time admits that 'it is now clear that ontogeny does not repeat phylogeny'.[40]

Some authors, however, remain quite aggressive in their defence of this argument:

> 'There are numerous other examples in which an organism's evolutionary history is represented temporarily in its development. Early in development, mammalian embryos temporarily have pharyngeal pouches, which are morphologically indistinguishable from aquatic vertebrate gill pouches. This evolutionary relic reflects the fact that mammalian ancestors were once aquatic gill-breathing vertebrates. The pharyngeal pouches of modern fish embryos eventually become perforated to form gills. Mammalian pharyngeal pouches of course do not develop into gills, but rather give rise to structures that evolved from gills, such as the eustachian tube, middle ear, tonsils, parathyroid and thymus. The arches between the gills, called branchial arches, were present in jawless fish and some of these branchial arches later evolved into the bones of the jaw, and, eventually, into the bones of the inner ear ... .'[32]

The fallacy in this argument lies in the fact that it assumes what it is trying to prove. It asserts that humans evolved from fish and that the seven human organs mentioned evolved from gills. That is the reason the author says the human pharyngeal pouches are 'morphologically indistinguishable' from fish gill pouches, not because of any anatomical and embryological evidence. Once again, the ideology, not the scientific evidence, is driving the evolutionary argument.

Some evolutionists know that they are misrepresenting the evidence. A recent article in the influential *Discover* magazine published a diagram showing four animals in the embryonic stage of development (a reptile, bird, pig, and human) to illustrate various structures, including one labeled 'gill pouches.'[33] A follow-up letter to the author noted that 'no informed scientist believes these ridged structures have any relationship to gills, either embryonic or fully developed'.[34] The author responded to this correspondence as follows:

> 'All vertebrate embryos possess, at one time or another, what many textbooks describe as "bronchial arches" (literally, "gill arches"). Other texts call these "pharyngeal arches", a term that is perhaps more accurate, because parts of these structures develop into gills only in fish and some amphibians. In humans, pharyngeal pouches (a component of the arches) develop into structures like the ear canal and tonsils. Therefore, I agree that the [term] "gill pouches" in both the text and the figure could have been more accurately termed "pharyngeal arches".'[35]

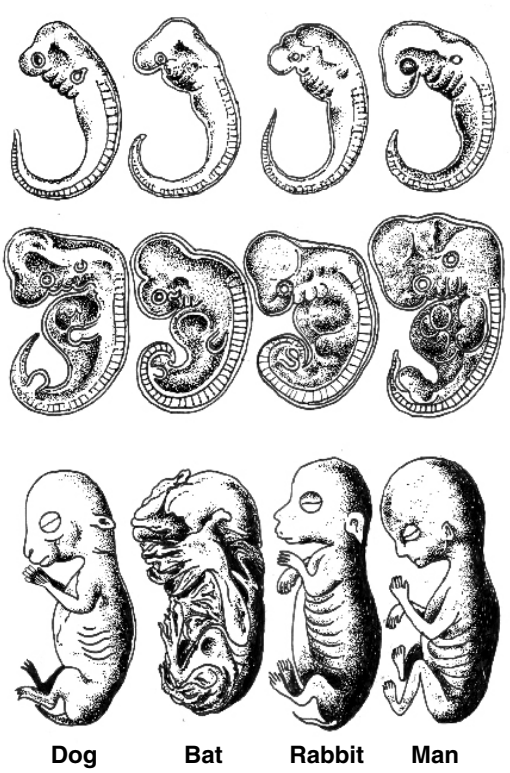

Figure 2. *Haekel's fraudulent drawings (top row) and illustrations of actual embryos (middle row).*

What the experts say

In a review of the history of embryology, Oppenheimer suggested that the German anatomist Martin Heinrich Rathke (1793–1860), in the mid-1800s, was the first to claim that gill slits exist in the mammalian embryo.[36] Asimov claimed that Rathke actually discovered 'gills, which, however did not persist as the animal developed.[37] This 'discovery' was not based on microscopic histological evaluations however, but on superficial gross morphology. And even these gross morphology evaluations were erroneous. The alleged gill slits were in the *throat region* below the chin, whereas in fish, the gill slits and their precursors are *on the side of the head*. But once this idea was proposed, it became part of the staple of evolutionary icons.

Hickman *et al.* admit that 'the gill arches serve no respiratory function in either embryos or adults ...'.[38] O'Rahilly and Müller plainly state that 'the pharyngeal clefts of vertebrate embryos ... are neither gills nor slits'.[39] Blechschmidt is even more forceful, concluding that 'the so-called basic law of biogenetics is wrong. No buts or ifs can mitigate this fact.' He adds that the gill stage myth is 'not even a tiny bit correct or correct in a different form ... . It is totally wrong'.[40] This view is universally shared by mainstream embryologists. A computer search of several relevant databases, including *Biological Abstracts* and *Medline*, containing almost 21 million science literature records for the term 'gill slits' located 78 articles. Not one of these articles made the claim that human embryos

contained gill slits that were leftovers from the fish stage of human evolution. Most all of the articles discussed gill development or studies in various sea living animals. Furthermore, Blechschmidt notes that all organs and structures that have been studied in the embryo have turned out to be functional during some phase of development. Not a single evolutionary transitional, atavistic, or vestigial organ exists in any stage of embryological development.[40,41]

Table I. *Fates of the Pharyngeal Arch Tissue (from Sperber[42] and Moore and Persaud[48]).*

Fold Number	**Structural Fate**
1st	Maxillary, mandibular arch
2nd	Hyoid cartilage, contributes to middle ear bones
3rd	Parathyroid and thymus gland
4th	The 4th and 6th fuse to form the Thyroid cartilage
5th	A transitory structure that disappears almost as soon as it forms
6th	Cricoid and arytenoid cartilages of the larynx

The so-called gill slits are neither slits nor gills, but epithelial tissue located in the neck region of the embryo, which forms a set of alternating pouches and ridges variously called grooves, folds, or creases. These structures are now correctly called *pharyngeal ridges and pouches* by anatomists.[42–44] Although they superficially resemble the structure in fish that develops into gill slits, the human 'gill slits' are in the neck and throat area; in fish, the 'gill slits' are located on the side of the head adjacent to the neck area.[45] Furthermore, in fish these structures are literally slits that form openings to allow water in and out of the internal gills that remove oxygen from the water. Gill slits are required only for water-dwelling animals with gills. The 'gill-slit' region in humans does not contain even partly developing slits or gills, and has no respiratory function.[13] As Kardong notes the expression 'gill slits is a misleading term'.[45]

Nor do human pharyngeal pouches develop into homologous structures such as lungs or gill-like structures. They are not 'old structures' reworked into 'new structures' as some Darwinists contend. Rather, the developmental fate of these locations includes a wide variety of structures that become part of the face, the ear cavities, bones of the middle ear, muscles of mastication and facial expression, the lower jaw, certain neck parts, and the thymus, thyroid, and parathyroid glands.[46] Sadler accurately notes that the pharyngeal or bronchial arches are present by

> ' … the 4th and 5th weeks of development and contribute to the characteristic external appearance of the embryo. Initially, they consist of bars of mesenchymal tissue separated by deep clefts known as pharyngeal or bronchial clefts. Simultaneously, with development of the arches and clefts, a number of outpocketings, the pharyngeal pouches, appear along the lateral walls of the pharyngeal gut, the most cranial part of the foregut. ... Pharyngeal arches not only contribute to formation of the neck but also play an important role in formation of the face. At the end of the 4th week, the center of the face is formed by the stomodeum, surrounded by the first pair of pharyngeal arches.'[47]

Summary

Unfortunately the gill/gill slit theory remains an icon of evolution and persists in part because it has proven to be a persuasive argument for Darwinism. Although refuted long ago, because skin folds in early vertebrate embryos look superficially similar, many modern authors persist in uncritically citing this idea. Yet it is demonstrably false. Skin folds on the side of the embryonic fish *head* turn into perforated gill slits with associated gills and respiratory physiology in the adult. Skin folds in the *neck* region of the human embryo develop into a variety of different organs that have nothing to do with respiration. These facts are widely acknowledged in embryology and anatomy textbooks and scholarly reference sources, but the gill-slit claim is still found in some textbooks and popular sources that discuss Darwinism. Some textbooks do not directly state that humans have gills but rather they misleadingly imply that this by their use of terms such as 'gill pouches' or 'gill furrows'. Although most new texts (but not all) now omit this once-common idea, its persistence continues to influence people to accept Darwinism. We urge our readers to write to publishers who persist with this error and graciously ask them to correct it.

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References

1. Bergman, J., The rise and fall of Haeckel's biogenic law, *CRSQ* **37**(2):110–122, 2000.
2. Frair, W., Embryology and evolution, *CRSQ* **36**:62–66, 1999.
3. Moore, K.L. and Persaud, T.V.N., *The Developing Human; Clinically Oriented Embryology*, Fifth Edition, Saunders, Philadelphia, p. 608,

1993.

4. Hickman, C., Roberts, L. and Larson, A., *Integrated Principles of Zoology*, C. Brown, Dubuque, p. 161, 1996.
5. Wells, J., *Icons of Evolution: Science or Myth? Why much of what we teach about evolution is wrong*, Regnery Publishing Inc., Washington, 2000.
6. Oppenheimer, J., *Essays in the History of Embryology and Biology*, MIT Press, Cambridge, p. 221, 1967.
7. Darwin, C., *The Descent of Man and Selection in Relation to Sex*, John Murray, London, 1871.
8. Wells, J., Haeckel's embryos and evolution, *The American Biology Teacher* **61**(5):345–349, 1999.
9. Huxley, J., *The Wonderful World of Life; The Story of Evolution*, Garden City Books, Garden City, New York, p. 15, 1958.
10. Parker, G., *What Evolution Is*, Harvard University Press, Cambridge, pp. 30–31, 1931.
11. Kimball, J.W., *Biology*, Addison-Wesley, Reading, p. 545, 1965.
12. Spock, B. and Rothenberg, M., *Baby and Child Care*, 6th Edition, Dutton, New York, p. 301, 1992.
13. Milner, R., *The Encyclopedia of Evolution*, Facts on File, New York, p. 44, 1990.
14. Youngson, R., *Scientific Blunders, a Brief History of How Wrong Scientists Can Sometimes Be*, Carroll and Graf, New York, 1998.
15. Pennisi, E., Haeckel's embryos: fraud rediscovered, *Science* **277**:1435, 1997.
16. Richardson, M., Embryonic fraud lives on, *New Scientist* **155**(2098):23, 1997.
17. Richardson, M., Heterochrony and the phylotypic period, *Developmental Biology* **172**: 412–421, 1997.
18. Grigg, R., Ernst Haeckel: evangelist for evolution and apostle of deceit, *Creation* **18**(2):33–36, 1996.
19. Grigg, R., Fraud rediscovered, *Creation* **20**(2):49–51, 1998.
20. Assmuth, J. and Hull, E.R., *Haeckel's Frauds and Forgeries*, Examiner Press, Bombay and Kenedy, London, 1915.
21. Gould, S.J., *Ontogeny and Phylogeny*, Harvard University Press, Cambridge, 1977.
22. Holden, C., Texas resolves war over biology texts, *Science* **302**:1130, 2003.
23. Callahan, P., *The Evolution of Insects*, Holiday House, New York, p. 104, 1972.
24. Asimov, I., *The Wellspring of Life*, Abelard-Schuman, New York, p. 120–122, 1960.
25. Kent, G.C., *Comparative Anatomy of the Vertebrates*, Sixth Edition, Times Mirror/Mosby, St Louis, 1987.
26. Raven, P. and Johnson, G., *Biology*, Wm. C. Brown, Debugue, p. 396, 1995.
27. Solomon, E.P., Berg, L. and Martin, D., Biology, Saunders, Orlando, p. 383, 1999.
28. Myron, H., *Gill Slits in Humans*, University of Chicago sponsored Newton Electronic Community for science, math, and computer science, p.1; <newton.dep.anl.gov/askasci/zoo00/zoo00105.htm> 9 November, 2001.
29. O'Neil, D., *Classification of Living Things*, Palomar College, San Marcos, p. 3, 2001.
30. Topoff, H., A Charles Darwin (187th) birthday quiz, *American Scientist* **85**(2):104–107; p. 106, 2001.
31. Beck, W.S., Liem, K.F. and Simpson, G.G., *Life: An Introduction to Biology*, Third Edition, Harper Collins, New York, p. 500, 1991.
32. Theobald, D., 29 evidences for macroevolution, <www.talkorgins.org>, pp. 8–9, 2002.
33. Haseltine, E., Fear and evolution, *Discover* **22**(10):88, 2001.
34. Sisson, E., Something fishey, *Discover* **22**(11):12, 2001.
35. Haseltine, E., Eric Haseltine responds, *Discover* **22**(11):12, 2001.
36. Oppenheimer, ref. 6, p. 148.
37. Asimov, ref. 22, p. 120.
38. Hickman, C., Roberts, L. and Larson, L., *Integrated Principles of Zoology*, McGraw Hill, New York, p. 175, 2001.
39. O'Rahilly, R. and Müller, F., *Human Embryology & Teratology*, Wiley-Liss, New York, p. 9, 1992.
40. Blechschmidt, E., *The Beginnings of Human Life*, Springer-Verlag, New York, p. 32, 1977.
41. Blechschmidt, E. and Gasser, R.F., *Biokinetics and Biodynamics of Human Differentiation; Principles and Applications*, Charles C. Thomas, Springfield, p. 125, 1978.
42. Sperber, G., *Crainofacial Development*, B.C. Decker, Hamilton, Ontario, 2001.
43. Su, D-m., Ellis, S., Napier, A., Lee, K. and Manley, N.R., *Hoxa3* and *Pax1* regulate epithelial cell death and proliferation during thymus and parathyroid organogenesis, *Developmental Biology* **236**:316–329, 2001.
44 Menton, D., Is the human embryo essentially a fish with gills? *St. Louis MetroVoice* **3**(12):C1, 1993.
45. Kardong, K.V., *Vertebrates: Comparative Anatomy, Function, Evolution*, Third Edition, McGraw Hill, New York, p. 52, 2002.
46. Manley, N.R. and Capecchi, M.R., Hox group 3 paralogs regulate the development and migration of the thymus, thyroid, and parathyroid glands, *Developmental Biology* **195**(1):1–15, 1998.
47. Sadler, T.W., *Langman's Medical Embryology*, Williams and Williams, Baltimore, p. 312, 1995.
48. Moore and Persaud, ref. 3, p. 191.

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