The Rise and Fall of Haeckel's Biogenetic Law

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Abstract

Evolutionists once commonly believed that all basic life forms which existed in our past multi-millions of years of evolution were rapidly repeated in the few months between conception and birth or hatching. Called the biogenetic law, this belief concluded that all embryos always rapidly pass through their evolutionary history, starting with the one cell stage, then in the case of humans developing into the fish stage, the reptile stage, the mammal stage, ape stage, and finally into a human-child stage. This theory, commonly explained as "ontogeny recapitulates phylogeny," was cited as a major proof of evolution for over a century. This paper also reviews many of the biogenetic law claims commonly used in pre 1960's textbooks including the gill slits, tail, and yolk sac. Recent discoveries in the field of embryology and a reevaluation of the evidence for the theory has shown it is without foundation and now largely has been discarded by embryologists.

Introduction

Many evolutionists once believed that as the human embryo developed it passed through most of its major past evolutionary stages through which it was believed to have evolved. These people taught that human life begins as a single cell as did the first life forms, then grows 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.

Although by the end of the 1920s the theory had, in Gould's words (1977a, p. 216), "utterly collapsed," it is ironically still mentioned as proof of evolution. As recently as 1987 it was claimed that many of the higher evolved animal embryos passed through "identical" evolutionary ancient stages before acquiring their unique modern features (Kent, 1987). This concept, called both the *biogenetic law* and the *embryonic recapitulation law* (or just the recapitulation law), is summarized by the expression "ontogeny recapitulates phylogeny" which means that "the development of the individual repeats the evolution of the race" (Moore, 1963, p. 608). The recapitulation law states that each successive stage

> in the development of an individual represented one of the adult forms that appeared in its evolutionary history. The human embryo with gill depressions in the neck was believed, for example, to signify a fishlike ancestor. On this basis Haeckel gave his generalization: *ontogeny (individual development) recapitulates (repeats) phylogeny (evolutionary descent)*. This notion later became known simply as *recapitulation* or the *biogenetic law* (Hickman et al., 1996, p. 161).

In the words of Princeton's Conklin:

> ontogeny, or the origin of individuals, and phylogeny, or the origin of races, are two aspects of one and the same thing, namely, organic development. There is a remarkable parallelism between the two, and in particular the factors or causes of development are essentially the same in both (1928, p. 64).

In other words, its embryonic stages reveal the development which an animal has gone though

> ...in the course of its evolution. Embryonic development is a brief and condensed repetition of a series of ancestral stages through which the race has passed. Or, as often stated, ontogeny (the development of the individual) recapitulates phylogeny (the development of the race). (Haupt, 1940, p. 345).

Some authorities have even tried to apply the biogenetic law to plants:

> Even in plant development we see recapitulation. Germinating moss and fern spores produce a short filament of green cells which resembles a filamentous green alga. Soon the moss protonema develops into the male and female leafy shoots, while the filament of fern cells develops into the mature prothallus. For a brief period, though, mosses and ferns both pass through a stage reminiscent of the algae from which we think they evolved (Kimball, 1965, p. 546).

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A review of older biology textbooks reveals that the biogenetic law was considered "one of the most important sources of biological evidence for evolution" and for this reason was for years almost always discussed in textbooks that covered biological evolution (Smallwood, 1930, p. 392). Many biology texts still try to argue that the resemblances embryos display to their putative ancestors as they develop is an important proof of evolution.

The biogenetic law was even widely taught in popular lay books such as Dr. Spock's *Baby and Child Care* which sold over 40 million copies in 39 languages. Under the subheading "They're repeating the whole history of the human race" Spock wrote watching a baby grow is "full of meaning" because the development of each 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. It's just at that time that babies are learning to use their fingers with skill and delicacy. Our ancestors stood up because they had found more useful things to do with their hands than walking on them (Spock, 1992, p. 301).

As we will see, this once common conclusion has been shown to be incorrect (McNamara, 1999). Nonetheless, the influence of the biogenetic law in convincing the public of the validity of macroevolution has been enormous, and it still is commonly mentioned in science text books even though it has been totally refuted.

> So great was the desire on the part of some to strengthen this [biogenetic] idea, that a classic series of drawings showing embryonic similarities was produced in which the resemblances of the embryos of fish and man were remarkable. They were so remarkable, in fact, that further investigation showed that overzealous artistry had indicated a few resemblances that did not quite exist! (Moore, 1963, p. 608)

The Basis of the Theory

Extensive comparisons of most developing animals has confirmed that a great deal of similarity exists in both the structure and function of body morphology including skeletons, muscles, nerves, body organs and cell ultrastructure. For example, Haupt argues for evolution by claiming that fish gill slits exist during human embryo development and that

> the heart is two chambered and the circulatory system distinctly fish-like. The heart then passes through a three-chambered stage, characteristic of amphibians and reptiles, and finally becomes four chambered, as in birds and in other mammals. Similarly the human brain, in its embryonic development, passes through a series of stages corresponding to adult conditions in the lower vertebrate groups (1940, p. 347).

Embryos of different species share similar structures, and they often appear physically similar, at least superficially, especially in their earlier stages of development. Although in the zygote, cleavage, blastula, gastrula and other stages of development many animal kinds often look very similar, they contain profound differences.

Especially do all vertebrates from amphioxus to humans share fundamental resemblances, but even here many thousands of differences exist. As biological research progressed, more and more differences between fetal development and the life forms the animal supposedly evolved from were discovered, eventually disproving the biogenetic law. One major difference in life is their DNA which differs by many hundreds of thousands or millions of base pairs which eventually results in the more obvious morphological differences that result from the divergence that occurs in the animal's later developmental stages (Richardson et al., 1997).

Even the eggs of many animals display profound differences. Vertebrate eggs vary greatly in size, ranging from the microscopic eggs of mammals to the enormous eggs of birds. Eggs also differ in the conditions under which is necessary for them to develop: some eggs begin as naked cells independent of their parents; others are enclosed in both protective membranes and shells and are incubated by their parents. Still other eggs such as those of humans develop within the body of the mother. Associated with these varying conditions of development are many differences in egg size, rate of development, and methods of nutrition.

Modern History of Biological Recapitulation

The theory that the existence or the "ontogeny" of the fetus "recapitulates" or duplicates the evolution of the race was probably first expounded in modern times by Kielmeyer in 1793 partly from the observation that a frog tadpole resembles a fish (Rusch, 1969). The theory was then developed by Müller in 1864, and later embryologist Karl Von Baer (1792–1876) published his ideas on the theory in 1828. Darwin in chapter 14 of his book *The Origin of Species* further developed the idea that the embryo's evolutionary history was written in its developmental stages (Darwin, 1859). Later it was elaborated and popularized by a German professor of comparative anatomy by the name of Ernst Haeckel (1834-1919) spelled Häckel in German (Rusch, 1969).

The biogenetic law has proved critically important in converting people to evolution, and for over a century has been cited as a major proof of evolution in science textbooks from high school to graduate school (Taylor, 1984). One reason the law was popular with text book authors was because it was a simple, easily grasped concept that can be effectively illustrated by diagrams which superficially appeared to prove the theory. Even Darwin and Huxley were impressed with Haeckel's illustrations, although as research revealed more and more flaws in his idea, many scientists realized Haeckel's biogenetic law went "far beyond anything resembling science," and it later actually became "an embarrassment to Darwin himself" (Milner, 1990, p. 205).

In a review of the history of the biogenetic law and why it was important, Conklin claimed a law which taught that every animal climbs its own ancestral tree in its development from egg to adult was a "god-send" to evolutionists, and as a result the study of embryology was pursued with

> feverish zeal...Here was a method which promised to reveal more important secrets of the past than would the unearthing of all the buried monuments of antiquity—in fact nothing less than a complete genealogical tree of all the diversified forms of life which inhabit the earth. It promised to reveal not only the animal ancestry of man and the line of his descent but also the ...origin of his mental, social, and ethical faculties (1928, p. 70).

The biogenetic law influenced the direction of research and it also distorted conclusions about past research findings (De Beer, 1958). As Rusch (1969, p. 27) noted "in most cases, recapitulation was considered to be sufficient cause for the various stages in embryological development" discouraging research into the true causes. Nonetheless, doubts about the theory began to emerge very early in its history:

> For a time embryology was studied chiefly to learn the course of past evolution, but owing to the highly speculative character of such studies and to the differences of opinion as to what were original (palingenetic) and what were acquired (coenogenetic) characters, there gradually arose a widespread skepticism concerning the value of embryology for this purpose. Gegenbaur, in 1889, voiced the growing opinion among zoölogists in these words: "If we are compelled to admit that coenogenetic characters are intermingled with palingenetic, then we cannot regard ontogeny as a pure source of evidence regarding phyletic relationships. Ontogeny accordingly becomes a field in which an active imagination may have full scope for its dangerous play, but in which positive results are by no means everywhere to be attained. To attain such results the palingenetic and the coenogenetic phenomena must be sifted apart, an operation that requires more than one critical *granum salis*." (Conklin, 1928, pp. 70–71).

Since then as serious problems with the "law" accumulated, more and more scientists discounted the theory, some even declaring that no evidence exists that ontogeny ever recapitulates phylogeny and that Haeckel's "biogenetic law" has no foundation in fact (Rusch, 1969, p. 28). Many of the major difficulties in the theory were well known in biology as early as 1928:

> Inasmuch as many phenomena of development are mere adaptations to the conditions of embryonic or larval life and could never have been present in adult animals, Haeckel separated such characters, which he called "coenogenetic," from the truly ancestral ones, which he called "palingenetic." Unfortunately there was no certain method of always distinguishing these two types of embryonic characters, but in spite of this difficulty embryology was supposed to afford a short and easy method of determining the ancestral history of every group (Conklin, 1928, p. 70).

Other problems with the theory include the fact that no certain criterion existed by which the

> palingenetic or ancestral features of development could be distinguished from the coenogenetic or recently acquired ones, and what one embryologist regarded as ancestral another might consider a recent addition. Furthermore, when there were no living or fossil animals resembling certain embryological forms the fancy was given free rein to invent hypothetical ancestors corresponding to such forms. As a result of such speculations multitudes of phylogenetic trees sprang up in the thin soil of embryological fact and developed a capacity of branching and producing hypothetical ancestors which was in inverse proportion to their hold on solid ground (Conklin, 1928, p. 70).

Unfortunately, in his enthusiasm to prove the law and thereby vindicate evolution, the biogenetic law's major supporter resorted to outright fraud.

Fraud Proven

Many of Haeckel's drawings that he used to support his biogenetic law now have been proven to be grossly fraudulent. Richardson, an embryologist at St. George's Hospital Medical School in London, concluded that generations of biology students

> may have been misled by a famous set of drawings of embryos published 123 years ago by the German biologist Ernst Haeckel. They show vertebrate embryos of different animals passing through identical stages of development. But the impression they give, that

> the embryos are exactly alike, is wrong ... [Richardson] hopes once and for all to discredit Haeckel's work, first found to be flawed more than a century ago ...(Pennisi, 1997, p. 1435)

The fraud was evidently actually first exposed in 1868 by University of Basel comparative anatomy Professor L. Rütimyer and then by Wilhelm His (1831–1904) in 1874. Dr. His was a comparative embryologist and professor of anatomy at the University of Leipzig. He concluded Haeckel's drawings and conclusions were a gross distortion of the facts. In a review of His's work, Taylor argued that Dr. His proved Haeckel had engaged in blatant fraud and therefore Haeckel

> had eliminated himself from the ranks of scientific research workers of any stature (His 1874, p. 163). His, whose work still stands as the foundation of our knowledge of embryological development, was not the first to point out the deficiencies of Haeckel's work, nor indeed was he the last, yet Haeckel's fraudulent drawings have continued to the present day to be reproduced throughout the biological literature (Taylor, 1984, pp. 276–277).

Cambridge University biologist Pitman even claimed that after Haeckel formulated his 'fundamental biogenetic law' in 1868 he

> ...stated that the entire animal kingdom was descended from an organism resembling the gastrula—an early stage in the embryonic development of most animals. To support his case he began to fake evidence. Charged with fraud by five professors and convicted by a university court at Jena, he agreed that a small percentage of his embryonic drawings were forgeries; he was merely filling in and reconstructing the missing links when the evidence was thin, and he claimed unblushingly that 'hundreds of the best observers and biologists lie under the same charge' (Pitman, 1984, p. 120).

Assmuth and Hull (1915) even wrote a whole book on Haeckel's many frauds and forgeries, concluding that Haeckel knowingly and deliberately falsified documents in an effort to convince readers of the validity of evolution. Nonetheless, for scientific reasons alone, the early promising start of the new theory soon fell on hard times even though many biologists contemporary to Haeckel thought that embryology:

> would be a golden key to problems of phylogeny. Yet there was much unsound biology associated with the Biogenetic Law, and *few aspects of evolutionary science have been so heavily attacked in recent years* (Dodson, 1960, p. 51 emphasis mine).

The major reason for the attack was that as "biological knowledge increased ... the biogenetic law has been subjected to considerable criticism" (Carlson, 1996, p. 39). Soon it was clear that the law was lethally flawed even though some Darwinists still clung to remnants of it. Its flaws were openly discussed in mainline textbooks as early as 1963:

> The similarities of embryological development among multicellular animals were intensively studied during the latter half of the nineteenth century. These studies led to the conclusion that the embryonic development of the individual repeated the evolutionary history of the race. Thus, it was thought to be possible to trace the evolutionary history of a species by a study of its embryonic development. This idea was so attractive as to gain the status of a biological principle ...Today the idea of embryonic resemblances is viewed with caution. We can see and demonstrate similarities between embryos of related groups ...However ...the old idea that a human passes through fish, amphibian, and reptile stages during early development is not correct (Moore, 1963, p. 608).

Richardson concluded from his extensive study of Haeckel's work that it may be "one of the most famous fakes in biology." This finding should not have shocked Haeckel's peers a century ago: Haeckel once admitted under pressure that he "used artistic license in preparing his drawings . . ." but Haeckel's confession was either forgotten or ignored by those who wanted to use his biogenetic law to support evolution (quoted in Pennisi, 1997, p. 1435). Later Haeckel's drawings were published in the 1901 English language book *Darwin and After Darwin*, and from here they were reproduced widely in English language biology texts for the next 80 years, no doubt because his pictures appeared to provide clear evidence of macroevolution.

Thanks to the work of Richardson et al. (1997, p. 91) the many fatal flaws in Haeckel's work have again resurfaced. Haeckel's drawings of embryos showed the 'tailbud' stage, close to identical for different species. The Richardson team found that embryos at the tailbud stage, which were thought to correspond to a conserved stage of evolution, actually show many major variations in form due to allometry, heterochromy, and differences in body plan and somatic number. These variations foreshowed important differences in the adult body form (Richardson et al., 1997, p. 91). Richardson believes studying the many *differences* in embryos may prove to be far more fruitful than focusing on the similarities.

Pennisi (1997, p. 1435) noted that while many types of embryos may share certain features at the early stages of development, including what appears to be a tail-like structure on their posterior and certain identifiable body segments, embryos of different animal types possess many major differences which negate the biogenetic theory. Evidence in favor of the biogenetic law was exploited by Haeckel, and the wealth of examples against the law were

ignored. For example, by the time human embryos have developed to the extent of having the number of body segments shown in Haeckel's drawing's they possess prominent protrusions called *limb buds* which later develop into limbs. These structures are absent in Haeckel's drawings.

Haeckel not only left out limb buds in his drawings, but even added structures to make the embryos of different animals appear more similar than they actually were. For example, he added a curl to the bird embryo "tail" so it would more closely resemble a human "tail." Haeckel even added features to the select few examples he used to prove his law, all of which were chosen because they seemed to prove his recapitulation theory. Furthermore, of the examples that Haeckel used, he fudged the scale by as much as 10 fold in order to exaggerate similarities among species. A comparison of Haeckel's drawings with accurate drawings or photographs show how enormously distorted, actually outright fraudulent, his drawings actually were (Rusch, 1969, pp. 29–31).

Haeckel also in most cases neglected to name the species he drew to illustrate his theory, falsely implying that the one representative he chose was representative of an entire group. Even closely related embryos such as those of different types of fish can vary greatly in appearance and developmental pathway (Carlson, 1996).

Far more variation exists in vertebrate embryos than was once assumed, and for this reason Richardson's work, by focusing on these variations, does "a great service to developmental biology" helping to better understand development (Gilbert quoted in Pennisi, 1997, p. 1435). As a result of Richardson's work and that of others, Haeckel's 1874 phylogenic tree based in part on the biogenetic law which was strongly influenced by "Darwin's theory of common descent ... including the unilateral progression of evolution toward humans... have since been refuted" (Hickman et al., 1996, p. 15). Dobson demonstrated that the biogenetic law fails when applied to echinoderms:

> The beautifully simple embryology of the echinoderms played an important role in the establishment of the Biogenetic Law. Yet the recent comprehensive study of echinoderm embryology by Fell reveals extensive differences among various groups of echinoderms, and these differences are referable to embryonic adaptions. Fell even casts doubt on the echinoderm-chordate relationship, for the hemichordate larva does not fit into the scheme of larval relationships which he has worked out (Dobson, 1960, p. 52).

Today the current most optimistic status of the "ontogeny recapitulates phylogeny" law was summarized by Trefil as follows:

> Nineteenth-century biologists noted that, as an embryo of an advanced organism grows, it passes through stages that look very much like the adult phase of less advanced organisms ...In the nineteenth century, this so-called biogenetic law was taken to prove that evolution had proceeded on more or less a straight line from the simplest organisms to its epitome in human beings. We no longer have this view of evolution, but the biogenetic law remains a useful generalization about the way an embryo develops (Trefil, 1992, p. 23).

Although most current textbooks no longer use Haeckel's fraudulent drawings, some evolutionists still ignore the overwhelming evidence against recapitulation theory and use the often vague similarities among developing species to argue for Haeckel's theory or a watered down version of it (Rusch, 1969, p. 34). Haeckel's drawings were even prominently displayed on the cover of a recent college text (Gerhart and Kirschner, 1997) and reproduced inside (p. 329) as if they were valid. Drawings similar to Haeckel's were also pictured on an advertisement for another recent college embryology text, but interestingly, Haeckel's ideas were never mentioned in the text itself (Gilbert and Raunio, 1997). The importance of the drawings was noted by Youngson:

> How did Haeckel get away with his theory for so long? It was largely, unfortunately, on the basis of his drawings. These became famous and have been repeatedly reproduced by publishers over the course of the last 120 years or so (1998, p. 176).

Many biologists also unthinkingly still cling to some remnants of the biogenetic law. An example is the often repeated claims about fish gill slits which is discussed in greater detail below.

The Putative Gill Slits

To make the ontogeny theory more plausible, its remaining advocates are forced to drop many stages of it and alter numerous major parts of the putative recapitulation path. Some contemporary Darwinists have dropped most of the historically accepted ontogeny stages and claim that only *three* stages are actually revealed in embryology: the fish, tail and hair stages. The major evidence for the fish stage are the "gill slits" evolutionists long claimed were present in human embryos in the early developmental stages (Haeckel, 1920, pp. 328–332). One now classic biology textbook claimed that all vertebrate embryos have gill slits, and that the gill slits "become functional only in the fishes and amphibians ...but their appearance in all vertebrates is indicative of descent from aquatic ancestors" (Haupt, 1940, p. 347). Another, more recent text under a set of drawings similar to Haeckel's asked:

> Isn't the resemblance striking? You might mistake one for another at an early stage in their growth. Notice that each embryo, whether it be fish, bird, or

> mammal has a tail and gill slits (Figure 41-3). Each also has a two-chambered fish heart. Animals that live in water like the fish have gill slits and breathe by means of *gills*. Yet the embryos of the reptile, the bird, and the mammal also have gill slits—though they never breathe by gills. These animals breathe by means of lungs. As embryos of different animals develop, they begin to differ from one another in structure, and the number of likenesses becomes fewer. However, the great similarity in structure of the early embryos of the fishes, amphibians, reptiles, birds, and mammals points to a common fish-like ancestor for the vertebrates (Gramet and Mandel, 1958, pp. 560–561).

Another more objective account which is still influenced by the "gill slit" misconception explains:

> The month-old human embryo has a series 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 (Kimball, 1965, p. 545).

These so called gill slits are actually a set of folds or creases in the neck region called pharyngeal pouches which only superficially resemble the gill slits that develop in fish to allow it to remove oxygen from the water through its gills. The gill slit area in non-fish does not contain even partly developing gills and has no respiratory function, nor does it develop into gills or gill like structures. It is now known that these structures develop into ear cavities, lower jaws and neck parts. An accurate description of the development of this area follows:

> The most typical feature in development of the head and neck is formed by the pharyngeal or bronchial arches. These arches appear in 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 (Sadler, 1995, p. 312).

Because the folds do not open into the throat or anywhere else, and are not either developing gills or slits, the term gill slits is a misnomer left over from the misleading biogenetic law. For this reason the classic embryology text by Langman stated that:

> The pouches penetrate the surrounding mesenchyme but do not establish an open communication with the external clefts. Hence, although development of pharyngeal arches, clefts, and pouches resembles formation of gills in fishes and amphibia, in the human embryo real gills (branchia) are never formed. Therefore, the term pharyngeal (arches, clefts, and pouches) has been adopted for the human embryo (Sadler, 1995, p. 312).

Many researchers recognized as long as 37 years ago that numerous differences existed between the pharyngeal arches and gill slits and one

> great difference between the arches in fish and man is that whereas the closing membranes break down in the fish to form the gill slits, they never do so normally in the human being (Harrison, 1963, p. 102).

A survey of 45 recent college level biology textbooks revealed that most did not mention the once common gill slit teaching as evidence for evolution, whereas almost all pre-1950s books surveyed did. One exception actually said that "fish, reptiles, birds, and humans all share in their early development ...gills and a tail" (Raven and Johnson, 1988, p. 322). Another stated: "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" (Solomon, Berg, Martin, 1999, p. 383).

Some evolutionists in their enthusiasm to prove evolution once even claimed that at one point in development the human embryo actually developed gills and resembled a tadpole, a claim that is totally false (Wells, 1999). As early as 1946 it was well recognized that the gill slit theory needed to be reexamined. The explanation often given for certain traits existing in the embryonic human heart and early circulatory system is that

> ...they are vestiges of ancestral conditions. Away back in Devonian times, according to this theory, the ancestors of men were aquatic, and the tendency to form gills and a gill circulation still persists. It is an application of the recapitulation theory ...[which as] ...an argument for details of ancestral structure the theory is totally unreliable; the fact that the early mammalian embryo has fetal membranes does not indicate that the adult ancestors of mammals had similar structures. At most we may say that certain embryonic structures, such as mammalian gill clefts, *suggest* aquatic ancestry. A truly scientific procedure

> is to try to find reasons for gill folds (that is all they are in mammals) in the needs of the embryo itself rather than in its ancestors, just as we do for the precocious development of the brain and eye or for the function of the fetal membranes ...The caution suggested here seems desirable in the interest of genuine science. Recent advances in genetics and endocrinology are bringing to light data that may eventually revolutionize our outlook on evolutionary history (Hauber and O'Hanlon, 1946, p. 252).

When their advice was finally heeded and the "truly scientific" procedure was followed, the reason for the gill folds in the embryo became apparent, and this information is now part of most up-to-date human anatomy textbooks.

The Human Tail

The putative human embryo "tail" which gradually is reduced until it usually disappears before birth, is also misinterpreted as an example of "recapitulation." This "tail" is actually the human spine and developing vertebra which ends in the coccyx. The "tail" appearance develops because the brain and spinal chord mature very early in development in order to help coordinate the rest of the body's development, and at this stage the developing spinal column is longer then the embryo torso.

It is for this reason that humans and most animals possess what superficially *appears* to be a tail during their early development. Tailed animals do not have a spinal cord or spinal vertebras in their tail as do the "tails" of embryo's. Unfortunately many older textbooks published highly misleading and often totally erroneous claims about the human embryo spine. A good example is Haupt's 1940 text which claimed embryology teaches that:

> many structures which are permanent in the lower members of a group appear only in embryonic stages in the case of the higher members, and then either later disappear completely, persist as vestiges, or become modified to form other structures. For example, during an early period of prenatal development, the human embryo has a tail as well developed as that of any of the other vertebrates (1940, p. 347).

A survey of modern biology textbooks showed that few today even mentioned the now disproven tail claims.

The Yolk Sac

Another structure that evolutionists once claimed was a useless remnant of the human evolutionary past and was a major evidence of the biogenetic law is the so-called yolk sac (Kaufmann, 1985). Darwinists once alleged that this structure was a remnant of our putative reptilian egg history. Many evolutionists maintained for years that the yolk sac is a non-functional vestige and another proof of the biogenetic law. Kent (1978, p. 435) stated that the "yolk sac of the mammalian embryo is vestigial" in the fourth edition of his text. For the sixth edition he expanded the discussion on the yolk sac considerably, giving in detail its many functions, and noting only that a yolk sac is "a reminder" of the mammalian "genetic relationship with egg-laying reptiles" (1987, p. 435). In response to the claims by creationists that the yolk sac has a function, Sillman stated in all his years as a biologist scanning the scientific literature that he

> ...can't recall a single reference in the scientific literature to a "proven" function for the yolk sac in the human embryo. In fact, both yolk sac and allantois, two embryonic membranes that are definitely functional in fish, amphibian, reptile and bird embryos, are vestigial in placental mammals. Their appearance in human (or mammal for that matter) embryos certainly does indicate a genetic kinship with the other vertebrates. It doesn't "prove" evolution occurred—but it does quite clearly, along with a host of other structures and functions, point to genetic linkage of all the vertebrates (Sillman, 1985, p. 1).

In contrast to Sillman's claims, the yolk-sac has now been proven to be a multifunctional organ critical for embryonic life. The classic anatomy text by Hole notes that the yolk sac forms during the second week of development, and has many functions including it produces

> blood cells in the early stages of development and gives rise to the cells that later become sex cells. The yolk sac also gives rise to the stem cells of the immune system. Portions of the yolk sac form the embryonic digestive tube as well. Part of the membrane derived from the yolk sac becomes incorporated into the umbilical cord, and the remainder lies in the cavity between the chorion and the amnion near the placenta. The allantois forms during the third week as a tube extending from the early yolk sac into the connecting stalk of the embryo. It, too, forms blood cells and gives rise to the umbilical arteries and vein. (Shier, Butler and Lewis, 1999, pp. 905–906).

The yolk sac's role is eventually taken over by other structures as the organism develops. For example, the yolk sac has a temporary role in producing blood cells before functional bone marrow is formed, and the yolk sac is discarded after the bone marrow develops. We now know that this structure is also critical for development for other reasons as well:

> During organogenesis and before the placental circulation is established, the yolk sac (YS) is the primary source of exchange between the embryo and the mother. The YS has nutritive, endocrine, metabolic, immunologic, secretory, excretory, and hemo-

> poietic functions... [which serve to transport] critical substances from the mother to the fetus at a time when the YS is the sole or principal maternofetal transport system. (Lindsay et al., 1992, p. 115)

Furthermore, Lindsay et al. (1992, p. 115) found the yolk-sac to be so important that "A persistently abnormally shaped YS is also useful as a predictor of an abnormal [developmental] outcome ...When the YS shape was persistently abnormal ...the outcome was always abnormal." One reason why this is true is, the yolk sac "plays an important role in the maternofetal transport system. Gross changes in its size or shape, therefore, could indicate or reflect significant dysfunction of this transport system" (Lindsay et al., 1992, p. 118).

The Embryological Down or Lanugo

During the so-called hair stage of embryo development, an extremely fine soft downy hair known as *lanugo* or *embryonal down* covers the embryo (Harrison ,1963). Evolution once taught that this hair was evidence of our primate and mammalian stage of evolution and has no function today. We now know that this hair plays an important role in both embryo and fetal development. Early in development a sticky white secretion (the *vernix caseosa*) covers the skin to protect the developing embryo from the corrosive effects of the surrounding amniotic fluid (Butler and Juurlink, 1987). Lanugo hair is most prominent during the seventh and eighth month of fetal development and serves to hold the *vernix caseosa* in place. As the embryo develops, the skin thickens and is keratinized. Consequently, the lanugo hair no longer is needed, and as a result almost all of the lanugo hair is lost just before birth (Carlson, 1996, p. 362).

Some of this downy hair persists throughout life on certain parts of the body, especially on the face and ears. This fuzz is not comparable to the coarse pelts of hair existing on mammals but still can be very useful in certain situations even in adult humans (DuPuy and Mermel, 1995). The outer layer of skin is highly keratinized "dead" epithelial cells and is useless for tactile sensations; therefore, these hairs are necessary to increase tactile sensitivity in order to enable the skin to communicate more effectively with the outside world. Downy hair also can develop extensively over the entire body during famine or in anorexics "to replace the insulation lost by the decrease in body fat" (DuPuy and Mermel, 1995, p. 179).

Other Problems With the Biogenetic Law

A major problem with the "conserved stage" hypothesis of recapitulation is that different organs develop at different times in different species, making it impossible to point to a single conserved stage when all species have the same body plan (Richardson, 1997b). The biogenetic law originally tried to explain virtually *all* aspects of development:

> Man no less than other mammals develops from a fertilized egg, which passes through cleavage, blastula, and gastrula stages. The human embryo has gill slits and aortic arches, which undergo exactly the same transformations that take place in other mammals. Man's heart is at first like that of a fish, consisting of one auricle and one ventricle. His backbone begins as a notochord, is next a segmented cartilaginous rod, then each segment or vertebra consists of five separate bones, and finally each fuses into a single bone. He has in the course of his development three different pairs of kidneys, first a pronephros (or fore-kidney), like that of the lower fishes, then a mesonephros (or mid-kidney), like that of the frogs, and finally a metanephros (or hind-kidney) like that of reptiles, birds, and mammals, which alone survives the adult. His brain, eye, ear, in fact, all his organs, pass through stages in development that are characteristic of lower vertebrates. Even in those adult features that are distinctively human, such as the peculiar form of the hand and the foot, the number of bones in the ankle and wrist, the number of pairs of ribs, the absence of a tail and the relative hairlessness of the skin—in all these respects the human foetus resembles anthropoid apes more than adult man. Why are not these and a hundred other structures made directly? Why this roundabout process of making a man? There is no answer but evolution (Conklin, 1928, pp. 74–75).

The law now is widely recognized as both erroneous and misleading because so many exceptions were found. Another major reason why it is flawed is for the reason that Haeckel based his biogenetic law on the

> flawed premise that evolutionary change occurs by successively adding stages onto the end of an unaltered ancestral ontogeny, compressing the ancestral ontogeny into earlier developmental stages. This notion was based on Lamarck's concept of the inheritance of acquired characteristics (Hickman et al., 1996, p. 161).

Probably the major reason the law was disproved was, because organ development was often contrary to what recapitulation predicted. For example, if the human embryo repeated its assumed evolutionary ancestry as it developed

> the human heart should begin with one chamber and then develop successively into two, then three, and finally four chambers. Instead, the human heart begins as a two-chambered organ which fuses to a single chamber, which then develops directly into four chambers. In other words, the sequence is 2-1-4, not 1-2-3-4 as required by the theory. The human

> brain develops before the nerve cords, and the heart before the blood vessels, both out of the assumed evolutionary sequence. It is because of many similar contradictions and omissions that the theory of embryological recapitulation has been abandoned by embryologists (Gish, 1995, p. 358).

Another excellent example is the development of similar forms of animals from very dissimilar pathways is common at later stages of development.

> Many types of animals pass through a larval stage on their way to adulthood, a phenomenon known as indirect development. For example, most frogs begin life as swimming tadpoles, and only later metamorphose into four legged animals. There are many species of frogs, however, which bypass the larval stage and develop directly. Remarkably, the adults of some of these direct developers are almost indistinguishable from the adults of sister species which develop indirectly. In other words, very similar frogs can be produced by direct and indirect development, even though the pathways are obviously radically different. The same phenomenon is common among sea urchins and ascidians (Wells and Nelson, 1997, p. 16).

Many other organs and structures have been found not to develop in the order predicted by the law. Examples Rusch gives include, in mammalian embryos the tongue develops before the teeth, and certain environmental conditions can change the sequence order that embryo differentiation occurs (1969, p. 28). Nor do anatomical evaluations of the developing embryo support recapitulation: "while many authors have written of a conserved embryonic stage, no one has cited any comparative data in support . . .the phylotypic stage is [evidently] regarded as a biological concept for which no proof is needed. This has led to many problems, not the least of which is the lack of consensus on exactly which stage is conserved." (Richardson et al., 1997).

Furthermore, the biogenetic law has misled researchers who for years were looking for evidence that does not exist and ignored or tried to explain away the large body of evidence that contradicted the biogenetic law.

Another major problem is recapitulation in development almost certainly would *not provide the animal with any selection advantages* but instead would likely result in many major selection *disadvantages* during the embryonic stage. The evidence supports Sir Arthur Keith's statement made three-quarters of a century ago regarding embryology and evolution that:

> It was expected that the embryo would recapitulate the features of its ancestors from the lowest to the highest forms in the animal kingdom. Now that the appearances of the embryo at all stages are known, the general feeling is one of disappointment; the human embryo *at no stage* is anthropoid in its appearance (1925, p. 867).

The many flaws which eventually mortally wounded the biogenetic law included the fact that it

> became *unfashionable in approach* (due to the rise of experimental embryology) and finally *untenable in theory* (when the establishment of Mendelian genetics converted previous exceptions into new expectations). The biogenetic law was not disproved by a direct scrutiny of its supposed operation; it fell because research in related fields refuted its necessary mechanism (Gould, 1977, p. 168).

As a result of our growing knowledge of biology and development, the law was actually largely discredited almost a half century ago even though it took decades before this new knowledge was reflected in the textbooks:

> Often cited as an example of recapitulation are the gill slits which occur during the embryonic development of reptiles, birds, and mammals. These have been considered to resemble the gill slits of adult fish, thus providing evidence of the racial history of the higher forms ...It was first advanced as a result of work upon the larval stages and embryos of animals. In the form above, it has been the subject of much criticism, and is not infrequently referred to as the "so-called Biogenetic Law." In the case of the gill slits cited, for example, it is pointed out that these structures in the embryonic stages of reptiles, birds, and mammals resemble the gill slits of the embryonic, not the adult, stages of fish... The Biogenetic Law was elaborated specifically to point out the significance of resemblances between embryonic stages of descendants and the adult stages of their ancestors. As we have seen, this concept is now largely discredited (Wilson, 1954, pp. 269–270).

Attempts have been made throughout the years to repair and revise the law, but all have failed. One early attempt offered by 19th century embryologist K. E. von Baer argued that early developmental features were *more* widely shared among

> different animal groups than later ones ...The adults of animals with relatively short and simple ontogenies often resemble preadult stages of other animals whose ontogeny is more elaborate, but the embryos of descendants do not necessarily resemble the adults of their ancestors. Even early development undergoes evolutionary divergence among groups, however, and it is not quite as stable as von Baer believed (Hickman et al., 1996, p. 162).

Why the Biogenetic Law is Still Taught

No reason now exists to believe that the recapitulation theory is true except that it appears to support evolution. Harvard's Steven J. Gould (1977) even wrote a 501 page book on Haeckel's biogenetic law documenting its history from its appearance in the pre-Socrates days to its demise in the early twentieth century. He claimed that the theory was one of the two or three leading scientific arguments for racism (1977, p. 216). The reason it is still taught is not because the realization that it is erroneous is recent: the biogenic law was recognized by many as long ago as one-half century as falsified:

> For a time during the latter half of the nineteenth century this theory was received with great enthusiasm, and it was predicted that a study of living things in the light of this "law" would revolutionize biology. But, unfortunately, the predictions are not being verified. As a working hypothesis the theory has been a great help, but there are so many exceptions, apparently even contradictions, that its application is frequently misleading (Hauber and O'Hanlon, 1946, p. 156).

Why, then, do many scientists at least nominally still accept biogenetic law? A major reason the biogenetic law or remnants of it are still taught in textbooks and at most colleges is because

> ...the biogenetic law has become so deeply rooted in biological thought that it cannot be weeded out in spite of its having been demonstrated to be wrong by numerous subsequent scholars. Even today both subtle and overt uses of the biogenic law are frequently encountered in the general biological literature as well as in more specialized evolutionary and systemic studies (Bock, 1969, p. 684).

Many scientists and writers are either unaware of the criticism of the law, or chose to ignore the evidence against it. Professor Glover claims that the "vast majority" of his medical students believe the human embryo has gill slits even though their medical text on embryology correctly explains that the human embryo does not have gill slits but pharyngeal groves (Ham, 1992). And Youngson concluded:

> While Haeckel's theory of recapitulation was, for a time, almost universally believed, the debunking of Haeckel was not widely known ... His book *The Riddle of the Universe*, an extraordinary mishmash of real science and imaginary nonsense, was a great popular success and ran into numerous editions. So, although his ontogeny ideas were brushed aside at a fairly early stage by the serious scientists, they continued to be accepted by the lay public (Youngson, 1998, p. 177).

Another major reason for the acceptance of the biogenetic law is because it is now part of the accepted worldview of scientists, a belief that they are exposed to from the earliest days of their training and are daily surrounded by. Most scientists are influenced by social pressure, and many fear recriminations from their fellow scientists if they do not conform to what is currently viewed as correct. To prove their orthodoxy, many scientists have become unscientific and have embraced the world view of twentieth century naturalism (Johnson, 1993).

This problem is no minor matter of interest only to creationists. The biogenetic law "became extremely influential outside of science" and "caused a great deal of mischief" (Milner, 1990). One example Milner cites is the idea that the brains of certain races were stuck at a lower, childlike stage of evolutionary development. In Gould's words, for "a half century the proponents of recapitulation had collected" evidence which "argued that adults of 'lower' races were like white children." Gould notes that proponents of recapulation asserted the fact that "women are more childlike in their anatomy than men" was proof of their inferiority (1977, pp. 219, 221). Gould gives many examples of the use of the biogenetic law to endorse racism, such as the argument that black males are more primitive then whites because the distance between their navel and penis remains small relative to body height as adults while white children begin with a small separation which increases during growth. The rising belly button was seen as a mark of evolutionary progress, because it could be used to rank the evolutionary level of other primates including the apes (1977, p. 218). Gould also noted that

> Recapitulation had its greatest political impact as an argument to justify imperialism. Kipling, in his poem on the "white man's burden," referred to vanquished natives as "half devil and half child." If the conquest of distant lands upset some Christian beliefs, science could always relieve a bothered conscience by pointing out that primitive people, like white children, were incapable of self-government in a modern world. During the Spanish-American War, a major debate arose in the United States over whether we had a right to annex the Philippines. When antiimperialists cited Henry Clay's contention that the Lord would not have created a race incapable of self-government, Rev. Josiah Strong replied: "Clay's conception was formed before modern science had shown that races develop in the course of centuries as individuals do in years, and that an underdeveloped race, which is incapable of self-government, is no more of a reflection on the Almighty than is an undeveloped child who is incapable of self-government (1977a, pp. 218–219).

Moore (1999, p. 1) even concluded that "recapitulation was a leading argument for racists in the late 19th century." Furthermore, some of Sigmund Freud's more radical now discredited ideas came directly from Haeckel's biogenetic

law (Milner, 1990, p. 177). Milner even claims Haeckel's views "became a major cultural force in shaping the militant nationalism in Germany" which led to the holocaust that resulted in the loss of over six million lives (1990, p. 205). This view of development has even been used as an argument to justify abortion in the early stages and is based on the reasoning that it is not wrong to kill life at this early development stage, because the embryo is not yet human, but only a fish or less (Major, 1994, pp. 175–177).

Implications for Creationism

The ontology law was a major weapon in the arsenal used to attack not only creationism but also Christianity, minorities and even the existing social order in favor of communism. Gould noted that recapitulation was Haeckel's favorite argument "to attack nobility's claim to special status—are we not all fish as embryos?—and to ridicule the soul's immortality—for where could the soul be in our embryonic, wormlike condition?" (Gould, 1997, p. 217).

Our ability to reason, to determine right and wrong, to live according to a conscience, to exercise domination over plants and animals, to enjoy music and art, and to worship our Creator are all only a small part of the enormous chasm that separates humans from *every other living creature*. The biogenetic law is only one of many hypotheses which evolutionists have used to try to support their naturalistic theory which is being gradually proven wrong as new evidence accumulates.

Naturalistic evolution requires faith in embryological theory that has now been disproved and belief in evolutionism requires a blind, often credulous faith induced partly by pressure to conform to the world of science which is saturated with naturalism. The history of the biogenetic law should force all persons to look critically at the current lack of evidence for the evolutionary model of origins.

Conclusions

The biogenetic law was based on very superficial similarities in developing embryos. As our knowledge of embryology and especially genetics increased, it became increasingly obvious that the "law" was fundamentally in error.

The three major early scientific objections to Haeckel's version of the biogenetic law can be summarized as follows:

1. The path of embryological development is not general for either organs or body structures. Each ontogenetic stage is an inseparable mixture of organs in different stages of putative ancestral repetition.
2. Larvae and embryos possess many features that help them adapt to their individual mode of life. New characters can be introduced at *any* stage of embryological development.
3. Development can be retarded as well as accelerated. Embryonic or larval stages of ancestors can become the adult stages of descendants—a phenomenon directly opposite to recapitulation (adapted from Gould, 1977, p.168).

The stages of embryological development of many animals show some similarities but the major reason for this is design constraints. Likewise adult organs show much similarity because only so many ways exist to design a heart or lung, and we would expect the *earlier* in development the *fewer* the design possibilities that exist. All sexual reproducing organisms start out as one celled zygotes which superficially look remarkably similar, and as development and differentiation proceed they look more and more different. All hearts begin as a single contracting artery tube which, depending on the animal type, develops into a one, two, three or four chambered heart. A human heart does not start as a simple one chambered heart because our ancestor had a one chambered heart, but because the process of embryological development mandates general simple to complex progression. The same is true for all other organs. Because all life initiates as one cell does not prove all life evolved from one cell, but that this is the only way that life can develop by either asexual or a sexual reproduction methods (Milton, 1997).

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Book Review

Show Me God by Fred Heeren
Day Star Publications, Wheeling, IL. 1995, Revised 1998, 393 pages, $23

As one who purports to be seeking scientific evidence for a Creator God, the author of *Show Me God* has been looking in all the wrong places. He has listed, often in technical detail, the pronouncements of secular researchers who are skeptics, agnostics, or atheists. Heeren finds that there is consensus as to the probability that the universe did have a beginning, that there is evidence of design in our solar system (the anthropic principle), and that it all began with a big bang some twenty billion years ago with galaxies and planets slowly condensing from clouds of gaseous matter.

The work of young-earth creationists is dismissed as inconsequential, and evidences for a young universe are ignored. Most often quoted as authorities in cosmology are Albert Einstein, Stephen Hawking, Fred Hoyle, and Robert Jastrow. Steven Jay Gould, Carl Sagan, Hugh Ross, and Richard Dawkins also are often cited in the copious notes at the end of each chapter. In short, the opinions of fallible human beings are accepted above the authority of God's inerrant Word. Wrong information is given as to the sources of recent creation "tradition" (p. 183).

The author must be given credit for wide-ranging research, describing even some of the most bizarre theories as to cosmic perceptions. He quotes physicist Robert Gange (p. 378):

> The deepest conclusion of quantum physics is that the only reason anything has physical existence is because of human consciousness. . . It's no longer *things* that are described by science, but *observations* that are described by science. . So what in point of fact *is*, is only because of human consciousness that is making observations through this particular oxygen-burning organic machine.

Such pronouncements remind one of the well-known quip, "Some people will believe anything as long as it isn't in the Bible."

Although Heeren himself professes belief in what he calls the IIP God—Infinite, Independent, Personal—he evidently feels compelled to try reconciling this belief with current theories of the cosmos. Chapter 9 is entitled "Alternative Explanations for Design" and describes various theories which try to avoid the necessity for a Designer.

Then, astonishingly, come chapters setting forth the author's deep belief in the Designer and in the Gospel. Entitled "Implications of Design" and "Is the Gospel Logical?" these chapters could have been written by the most devout evangelical preacher. There follows a chapter giving brief biographies of "Fifty Believers Who Led the Way in Science." Then, back to skepticism with the final chapters: "Everything You Ever Wanted to Know About 20" Century Cosmology" and "Q and A with Today's Leading Cosmologists."

Parts of the book consist of facetious, informal exchanges with an imaginary editor. Illustrations are frequent, and some of the photos of celestial objects are quite beautiful.

This book is the first in a proposed series of four "Wonders that Witness" volumes. But as long as the author continues to waver between two opinions (1 Kings 18:21) his work will only confuse, not enlighten seekers of Biblical and scientific truth. This book was also reviewed earlier (DeYoung).

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