Zombie Science

More Icons of Evolution

Jonathan Wells

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Description

In 2000, biologist Jonathan Wells took the science world by storm with *Icons of Evolution*, a book showing how biology textbooks routinely promote Darwinism using bogus evidence—icons of evolution like Ernst Haeckel's faked embryo drawings and peppered moths glued to tree trunks. Critics of the book complained that Wells had merely gathered up a handful of innocent textbook errors and blown them out of proportion. Now, in *Zombie Science*, Wells asks a simple question: If the icons of evolution were just innocent textbook errors, why do so many of them still persist? Science has enriched our lives and led to countless discoveries, but now, Wells argues, it's being corrupted. Empirical science is devolving into zombie science, shuffling along unfazed by opposing evidence. Discredited icons of evolution rise from the dead while more icons—equally bogus—join their ranks. Like a B horror movie, they just keep coming! Zombies are make-believe, but zombie science is real—and it threatens not just science, but our whole culture. Is there a solution? Wells is sure of it, and points the way.

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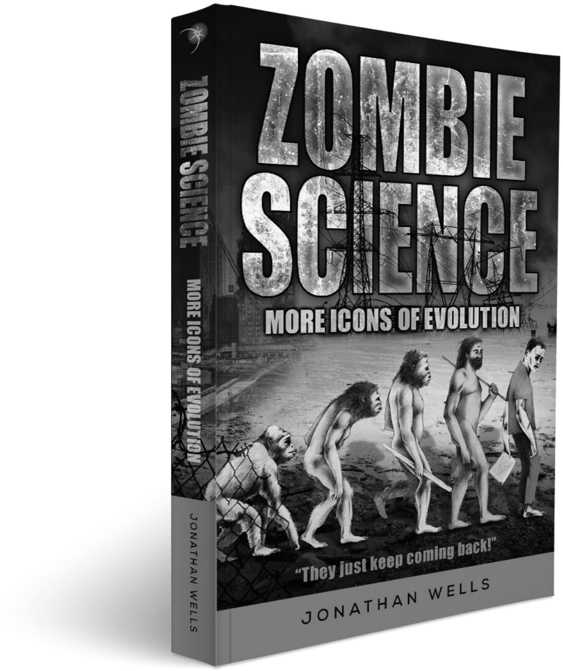

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Your one-stop location for additional information about biologist Jonathan Wells and the "icons of evolution," including articles, responses to critics, podcasts, and more.

5. Walking Whales

Darwin wrote in the first edition of *The Origin of Species* that North American black bears had been seen "swimming for hours with widely open mouth, thus catching, like a whale, insects in the water." What did this have to do with the subject of his book? "Even in so extreme a case as this," Darwin continued, "if the supply of insects were constant, and if better adapted competitors did not already exist in the country, I can see no difficulty in a race of bears being rendered, by natural selection, more and more aquatic in their structure and habits, with larger and larger mouths, till a creature was produced as monstrous as a whale."[1]

Critics poked fun at this, and Darwin removed it from later editions, but he defended it privately. "The bear case has been well laughed at, and disingenuously distorted by some into my saying that a bear could be converted into a whale," he wrote in an 1860 letter. "As it offended persons, I struck it out in the second edition; but I still maintain that there is no especial difficulty in a bear's mouth being enlarged to any degree useful to its changing habits,—no more difficulty than man has found in increasing the crop of the pigeon, by continued selection, until it is literally as big as the whole rest of the body."[2]

But of course bears with large mouths are a very long way from being whales. The evolution of whales long remained a problem for Darwin and his followers, until some fossils were discovered in the 1990s and strung together into a new icon of evolution.

The Fossil Record

Land mammals occur in the fossil record before whales. By 1859, fossils of two extinct whales had been found: *Dorudon* (a dolphin-like mammal about sixteen feet long) and *Basilosaurus* (a serpent-like mammal about sixty-five feet long). But *Dorudon* and *Basilosaurus* were both fully aquatic: Although (like other mammals) they had to breathe air, they spent their entire lives in the sea. So there were no fossil intermediates to justify a belief that land animals had evolved into whales.

In the early 1980s, the fossil of an extinct land animal the size of a wolf was discovered in Pakistan. Judging from the rocks in which it was found, it was older than *Dorudon* or *Basilosaurus*. Although the animal looked nothing like a whale, a bone in its middle ear resembled something that had previously been found only in whales, dolphins, and porpoises: a bone called an "involucrum." Whales, dolphins and porpoises are collectively called "cetaceans" (sĕ-TAY-shuns), from the Latin word "cetus," meaning whale. Although "whale" is traditionally defined as a large, fully aquatic mammal, the small fossilized land animal was named *Pakicetus*, or Pakistani whale, because of its involucrum.[3]

The possibility that the involucrum had originated more than once was not considered. The evolutionary story about whales needed an ancestor, and *Pakicetus* was the best candidate on hand. But *Pakicetus* was fully terrestrial, so merely calling it a whale did not fill the chasm between land animals and whales. Not surprisingly, critics of evolution continued to point to that chasm as a problem for Darwin's theory. As recently as 1993, a book critical of evolution stated that "there are no clear transitional fossils linking land mammals to whales."[4]

Walking Whales?

The very next year, however, paleontologist Hans Thewissen and his colleagues reported the discovery in Pakistan of a fossil older than *Dorudon* or *Basilosaurus* but younger than *Pakicetus*. The animal had legs that would have enabled it to walk on land like a modern sea lion, but it also had a long tail that would have enabled it to swim like a sea otter.

Thewissen and his colleagues interpreted the fossil to be intermediate between land animals and whales, and they named it *Ambulocetus natans*, or "swimming walking whale."[5] A few months later, paleontologist Philip Gingerich and his colleagues discovered a slightly younger fossil in Pakistan they interpreted to be intermediate between *Ambulocetus* and modern whales. They called their discovery *Rodhocetus*.[6]

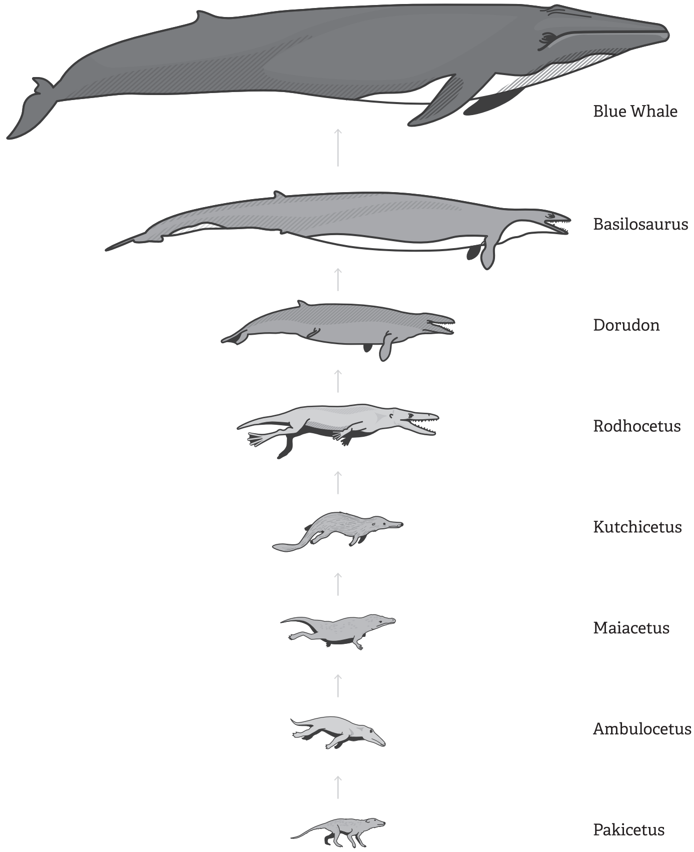

Figure 5-1. The Textbook Story of Whale Evolution: Artists' conceptions are arranged in roughly chronological order, based on positions in the fossil record.

"The embarrassment of past absence has been replaced by a bounty of new evidence," announced Stephen Jay Gould, "—and by the sweetest series of transitional fossils an evolutionist could ever hope to find."

According to Gould, "this sequential discovery of picture-perfect intermediacy in the evolution of whales stands as a triumph in the history of paleontology. I cannot imagine a better tale for popular presentation of science or a more satisfying, and intellectually based, political victory over lingering creationist opposition."[7]

So "walking whales" became an icon of evolution.

More fossils of mammals supposedly ancestral to modern cetaceans have subsequently been reported, including *Kutchicetus* in 2000,[8] *Indohyus* in 2007,[9] and *Maiacetus* in 2009.[10] Many textbooks use artists' conceptions of these animals to illustrate the evolutionary story of whales.

Like the textbook illustrations, Figure 5-1 distorts some things to fit the evolutionary story. *Basilosaurus* and *Dorudon* were contemporaries, and the fossil records of some of the others overlapped each other. All of the "walking whales" (those whose names end in *cetus*) are reconstructed from incomplete skeletons (*Pakicetus* was known only from a skull), and *Kutchicetus* was actually smaller than *Maiacetus* or *Ambulocetus*.

In any case, none of the fossils in Figure 5-1 were ancestors or descendants of the others. According to paleontologist Kevin Padian, this is because "*Ambulocetus, Rodhocetus, Pakicetus,* and other forms each have their own… distinguishing characteristics, which they would have to lose in order to be considered direct ancestors of other known forms."[11] So if there were animals ancestral to modern whales, these fossils would not represent them. The arrows in Figure 5-1 are not just imaginary; they are misleading.

Were They Really Whales?

As in textbook illustrations, the forms in Figure 5-1 between *Pakicetus* and *Dorudon* are drawn to show they were swimming, but they actually lived mainly on land. The *Maiacetus* that was described in 2009 by Gingerich and his colleagues was a pregnant female with a fetus inside it, and "the fetal skeleton is positioned for head-first birth, a universal birthing posture in large-bodied land mammals, but one that is anomalous in fully aquatic marine mammals."[12] In other words, the animal gave birth on land. According to Thewissen, *Maiacetus* was "most similar in skeletal proportions" to a "giant freshwater otter."[13]

So *Maiacetus*, like *Ambulocetus* and *Pakicetus*, lived primarily on land. *Kutchicetus* looked a bit like a long-snouted crocodile with short, weight-bearing legs.[14] *Rodhocetus* had smaller hind limbs; it may have moved like a sea lion on land, swum with a dog paddle on the surface of the water, and moved like an otter underwater.[15] None of these animals were really whales, or even close. Otters and sea lions are amphibious land animals that spend some of their lives in the water, but whales, dolphins and porpoises spend *all* of their lives in the water. Coming onto land is not a natural act for cetaceans; beached whales die if they are not quickly helped back into the water. Clearly, there are important differences between fully aquatic cetaceans and amphibious mammals such as otters and sea lions.

Pakicetus, the first "walking whale" to be discovered, was classified as a cetacean because it possessed an involucrum. Yet it turns out that *Indohyus* also possessed an involucrum, but it is not considered a cetacean. Instead, it is classified in the order of mammals that includes pigs, hippopotamuses, giraffes, antelopes, sheep, and cattle. Thewissen and his colleagues, who described *Indohyus*, wrote in 2007, "Until now, the involucrum was the only character occurring in all fossil and recent cetaceans but in no other mammals. Identification of the involucrum in *Indohyus* calls into question what it is to be a cetacean: It requires either that the concept of Cetacea be expanded to include *Indohyus* or that the involucrum cease to characterize cetaceans."[16] The authors argued for the latter—that the involucrum should no longer be used to characterize cetaceans.

In other words, the involucrum is diagnostic of cetaceans, except when it isn't. So why should we call *Pakicetus* a cetacean? Why not just call it what it was: a land mammal. And why should we call *Ambulocetus*, *Maiacetus*, *Kutchicetus*, and *Rodhocetus* cetaceans? Why not just call them what they were: amphibious mammals that spent part of their lives on land and part of their lives in water?

In other words, Gould's "sweetest series of transitional fossils" is missing the most important transition of all: the transition from living primarily on land to living entirely in the water.

What Does It Take to Make a Whale?

Fossils of the fully aquatic whales *Dorudon* and *Basilosaurus* appeared in a geological period called the Eocene, in rocks that geologists have dated to about forty million years ago. *Maiacetus, Kutchicetus,* and *Rodhocetus* were found in Eocene rocks dated between two and eight million years before that. So based on this fossil evidence, the transition from land mammals to fully aquatic mammals occurred in eight million years or less.

What changes would mammals have to undergo in those eight million years to transform them from terrestrial or amphibious mammals into fully aquatic ones? Quite a few. Many features of cetaceans differ dramatically from the features of terrestrial mammals. What follows is just a small sampling of them.

Features Needed for Swimming: A cetacean propels itself through the water primarily by the up-and-down movements of large projections at the end of its tail called "flukes." Except for tail vertebrae running down their centers, flukes contain no bones; they are made of fibrous connective tissue. Yet cetacean flukes are not passive flippers like those used by human scuba divers. Instead, their movements are coordinated by a complex system of long, powerful tendons connecting them to specialized muscles in the tail.

In the blue whale in Figure 5-1, the tail begins between the small dorsal fin and the flukes. The tail can be flexed up and down relative to the body, but the flukes can be moved independently of the tail. According to Everhard Slijper's classic book on cetaceans, the flukes "can be moved with respect to the other sections, so that the fact that, during motion, the flukes make an angle with the rest of the tail is not due to their passive reaction to the pressure of the water, as it is in the fish, but to an active muscular exertion." In the 1880s anatomists already knew "how complicated and how ingenious the structure of these organs really is."[17]

Flukes are shaped like airplane wings (called "foils"), with a rounded leading edge and long tapering trailing edge. Biologists who analyzed flukes in 2007 reported that "the relatively large leading edge radius allows greater lift generation and delays stall." In fact, calculations showed that "flukes were generally comparable or better for lift generation than engineered foils."[18]

Cetaceans also have dorsal fins, which stabilize them against roll. Like flukes, dorsal fins are among the features that distinguish cetaceans from terrestrial and amphibious mammals.

Features Needed for Breathing: A cetacean breathes by means of nostrils on top of its head, called "blowholes" because when the animal surfaces it blows moisture-laden air out of them. All living cetaceans have blowholes on the tops of their heads, though in a sperm whale the blowholes are situated farther forward than in other whales.

So for a land animal to have evolved into a cetacean, its nostrils would have had to relocate to the top of its head.

A blowhole is surrounded by thick "lips" consisting of highly elastic tissue. According to Slijper, this tissue "normally keeps the blowhole closed by tension even when the whale is at the surface. To open it during breathing, the whale has numerous muscles which run from the 'lips' to the skull below. Obviously, this method of closing the blowhole is much more effective" at keeping out water than the method found in seals, sea-lions and land mammals, whose nostrils are normally open and must be closed underwater by an active contraction of muscles.[19]

Although they breathe at the surface, cetaceans are famous for their deep dives. (Sea lions and seals, though not fully aquatic, are also famous for their deep dives.) Dolphins and porpoises can dive to depths of 300 meters; Weddell seals can dive to 600 meters; sperm whales can dive to 2,000 meters; and beaked whales can dive to almost 3,000 meters (over 9,800 feet).[20]

The pressure on an animal at the surface of the water is one atmosphere; the pressure on an animal ten meters below the surface is about two atmospheres; and the pressure increases about one atmosphere for every additional ten meters. So a sperm whale at 2,000 meters experiences about 200 times the pressure it experiences at the surface. Bones are not strong enough to protect lungs from such high pressure, so deep-diving mammals have collapsible rib cages and collapsible lungs.

The rib cages of cetaceans have a lot of "floating ribs," ones not attached to the sternum. These floating ribs greatly enhance the flexibility of the chest wall.[21] Cetaceans and other diving mammals also have diaphragms that are oriented nearly parallel to the spine rather than perpendicular to it. Anesthesiologist Richard Brown and physiologist James Butler explain that "the large area of contact between lung and diaphragm in cetaceans allows for the diaphragm to smoothly collapse the lung along the lungs' shortest dimension" (belly to back).[22]

Chest collapse has been directly observed in a dolphin at a depth of fifty meters, and observed by underwater television at a depth of 300 meters.[23] Blood tests have shown that seal lungs collapse by the time the animals reach a depth of fifty meters.[24] Those same tests, and similar tests in sea lions, reveal one reason why lung collapse is physiologically essential: By collapsing the tiny air sacs where gases are normally exchanged with blood, the diving mammal is protected from taking in too much nitrogen. Nitrogen absorbed under pressure causes a dangerously altered mental state called "narcosis." Even worse, nitrogen absorbed under pressure can produce bubbles in the body when the pressure is reduced, causing potentially fatal decompression sickness ("the bends").[25] By collapsing their lungs, deep-diving mammals avoid these problems.

A typical sperm whale dive lasts about an hour. A beaked whale dive may last more than two hours. How can cetaceans stay under water so long? It's thanks to yet another metabolic-engineering marvel.

Cetaceans have far more myoglobin (an oxygen-storage molecule) in their muscles than land mammals.[26] Nevertheless, as Slijper pointed out, "not even the large quantities of myoglobin they have provide an adequate explanation for their long stay under water… During diving, basic changes in the metabolism must occur."[27] The blood supply is redistributed to the brain and heart, the heart slows down, and muscles switch to anaerobic metabolism. All vertebrates do this to some extent when they are deprived of air, but deep-diving mammals do it more completely and efficiently.[28]

Deep, long dives pose a challenge, but so too does surfacing afterwards. When a cetacean surfaces after a dive, it must re-inflate its lungs quickly in order to breathe. Lungs contain fluids called "surfactants" that coat the linings of tiny air sacs to aid in gas exchange between the air and blood. Experimental results published in 2004 showed that lung surfactants in sea lions and seals have "a composition that is distinct from that of terrestrial mammals and may be uniquely suited to repetitive collapse and expansion of the lung."[29] The same is probably true of cetaceans. Other evidence published in 2006 showed that such surfactants have "primarily an anti-adhesive function to meet the challenges of regularly collapsing lungs."[30]

Some of the breathing features described above are not unique to cetaceans. Other deep-diving mammals have them, too. But blowholes are present only in cetaceans.

Features Needed for Reproduction: In most mammals, sperm production requires a temperature several degrees below normal body temperature. Thus the testicles of most terrestrial mammals are held outside the body, but male cetaceans have internal testicles, which must be cooled below body temperature despite the fact that they are surrounded by heat-generating muscles.

The cooling is accomplished with a counter-current heat exchanger. Blood that has been cooled in the dorsal fin and flukes is carried to a region near the testicles, where it flows through a network of veins that pass between arteries carrying warm blood in the opposite direction. The arterial blood is thereby cooled before it reaches the testicles[31,32] (See Figure 5-2).

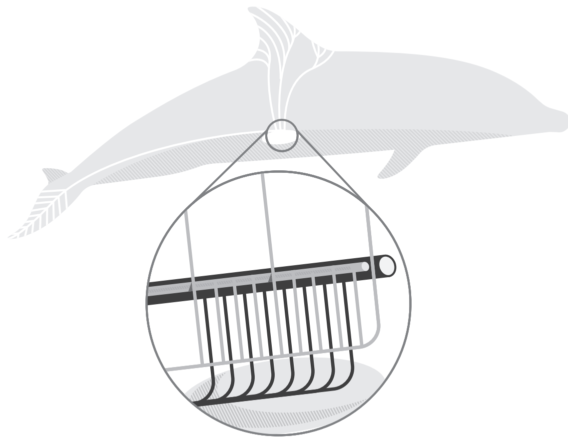

Figure 5-2. Simplified Diagram of Blood Circulation Around a Dolphin Testicle: In the body silhouette at the top, the white lines are veins. In the expanded view below, the black lines are arteries that carry warm blood from the heart. The gray lines are veins that carry cooled blood from the dorsal fin and the tail flukes. As the warm arterial blood flows down to the testicle, cool venous blood flows up between the arteries.

If this engineering arrangement were due to evolution, the relocation of cetacean testicles to the inside could not have preceded the counter-current heat exchange system. Otherwise, the whale would have been sterile, an evolutionary dead end. Yet there is no adaptive advantage to developing a counter-current heat exchange system around the testicles unless they are inside the body. One would not come before the other, yet the probability that both would evolve simultaneously is effectively zero.

Also, after birth, cetacean calves must be nursed underwater. But young calves cannot stay underwater as long as adults; they have to surface frequently to breathe. So nursing in cetaceans is very different from nursing in terrestrial mammals.

A cetacean mother's nipples are recessed in two slits on either side of the genital opening. According to Slijper, "While suckling their young, cetaceans move very slowly; the calf follows behind and approaches the nipple from the back. The cow then turns a little to the side, so that the calf has easier access to the nipple, which has meanwhile emerged from its slit. Since the calf lacks proper lips, it has to seize the nipple between the tongue and the tip of its palate."[33] (Even sperm whales suckle this way, though because of their unusual head anatomy calves must position themselves upside-down under their mothers.)[34]

The mother then forcefully squirts milk into the calf. Even after the calf lets go, milk can often be seen squirting from the nipple. The milk is three to four times as concentrated as the milk of cows and goats; it has the consistency of condensed milk or liquid yogurt. The calf thereby receives much more nourishment in a much shorter time.[35]

Thus many features would have had to originate in the eight million years or less between the so-called "walking whales" and fully aquatic whales, including flukes (along with fluke tendons and specialized tail muscles); blowholes (with elastic tissues to keep them closed and specialized muscles to open them); internal testicles (with a countercurrent heat exchange system to cool them); specialized features for nursing (including forceful delivery and concentrated milk); and many other features not listed here.

This is a tall order. Indeed, a growing body of evidence suggests that for evolution it's an insurmountably tall order.

Neo-Darwinism assumes that anatomical changes originate in DNA mutations. As we saw in Chapter 4, this assumption is false. Decades of experiments have shown that DNA mutations do not produce beneficial new anatomical features. But for the sake of argument, let's ignore that fact and proceed as though the standard evolutionary theory might be true. Let's also ignore, for now, the criticisms in Chapter 4 of the modern use of the word "gene." Ignore all that and evolutionary theory still faces a big problem.

Whale Genes?

Some genes have larger effects than others because they regulate other genes. According to Thewissen, hind limbs disappeared in cetaceans because of changes in regulatory genes, and "the same regulatory genes may also have effects on other parts of the dolphin's anatomy, and possibly those same genes were involved in shaping the other parts of the anatomy of the Eocene cetaceans."[36] But what genes might they have been?

Cetaceans are divided into two sub-orders: toothed and baleen. The first sub-order includes dolphins, porpoises, and sperm whales (among others). The second sub-order includes gray whales, right whales and blue whales (among others). Baleen is made of keratin, the same protein found in human hair and nails, but in baleen whales (which lack teeth) it forms large comb-like structures in the mouth used to strain food from the water the whales take in.

As we saw in Chapter 4, *Hox* genes are involved in specifying the locations of structures along the head-to-tail axis of animals, and similar *Hox* genes are found in many kinds of animals. In 1998, a team of scientists found that a gene affecting limb development in chicks and mice also occurs in baleen whales, but the whale version was missing some nucleotides. When they inserted the whale version of the gene into a mouse embryo, they found that it was not expressed in the place where mouse hind limbs would normally form.[37,38]

It might be tempting to argue that the missing nucleotides explain why whales lack hind limbs, though the authors of the 1998 studies did not argue that, and Lars Bejder and Brian Hall pointed out in 2002 that the missing nucleotides are *not* missing in other whales (all of which lack hind limbs). Bejder and Hall concluded, "A simple evolutionary change in *Hox* gene expression or *Hox* gene regulation is unlikely to have driven loss of the hind limbs in cetaceans."[39]

A genetic analysis published in 2011 concluded that baleen whales have genes for several proteins contained in enamel, but the genes have been inactivated by mutations.[40] This might help explain why baleen whales lack teeth, but clearly it does not explain why they have baleen.

Another genetic analysis published in 2014 concluded that various taste receptor genes in both toothed and baleen cetaceans had been inactivated by mutations.[41] Once again, however, the loss of features cannot explain the origin of features.

Mutations in a gene called *ASPM* cause severe reductions in brain size in humans. In 2012, a team of scientists used a molecular phylogenetic tree to infer that the sequence of *ASPM* had changed more in cetaceans and primates (both of which have large brains) than in other mammals. The scientists concluded that "positive [natural] selection at the *ASPM* gene coincides with brain size enlargements in cetaceans."[42] A 2014 study, however, pointed out that the 2012 study did not explicitly test for a connection between *ASPM* and brain size. According to the authors of the 2014 study, the conclusion of the 2012 study was "not supported."[43]

So the available evidence does not even come close to identifying genes that could turn a land mammal into a fully aquatic cetacean. In the absence of anything like direct evidence, let's consider a more indirect approach.

How Many Mutations?

As we saw above, the fossil record shows that the transition from terrestrial or amphibious mammals to fully aquatic cetaceans occurred in eight million years or less. Eight million years might seem like a long time, but if cetaceans evolved by the accumulation of accidental mutations in a land-dwelling ancestor, it might not have been long enough.

How many genes would have to change during those eight million years? Nobody really knows, of course, but a 2016 study of giraffes might provide some insight. An international team of biologists compared over 13,000 genes from giraffes and okapis. Okapis are similar to giraffes but have much shorter necks. The comparison showed that the giraffe has seventy genes that "exhibit unique genetic changes and likely contribute to giraffe's unique features."[44] According to the authors, about two-thirds of those genes have specific roles in regulating skeletal, neural, and/or cardiovascular development, and probably played a role in the evolution of the giraffe's long neck, modified nerves, and turbocharged heart (needed to pump blood to the elevated head).

The 2016 study estimated that the common ancestor of giraffes and okapis lived about eleven million years ago, so the time frame is not very different from the gap between "walking whales" and fully aquatic cetaceans. Let's begin by assuming that it took only one mutation to modify each of the giraffe's forty-six distinctive "neck genes." This is surely an underestimate, even if mutations could produce the beneficial anatomical changes needed for evolution. But for the sake of argument, let's assume that just one mutation per gene was sufficient for the evolution of the giraffe's neck—forty-six mutations in all.[45]

So now let's extrapolate from that figure to estimate how many mutations would be needed to evolve a whale from a land mammal. Lengthening the neck and modifying the heart and nerves in giraffes might be compared to lengthening the tail and modifying the muscles and nerves in cetaceans. But that does not include the origin of new features such as flukes and dorsal fins, top-of-the-head blowholes with their specialized musculature, internal testicles with their counter-current heat exchange system, or specialized features for nursing underwater. Unless we assume (quite unrealistically) that mutations in a few regulatory genes could produce all these effects, it is clear that at least hundreds or thousands of mutations would be needed to explain how "walking whales" evolved into modern cetaceans.

How long does it take for nature to generate and select that many mutations? Mutation rates have been experimentally determined for many different organisms.[46] Mutations occur in the course of reproduction, so the rate at which they occur depends on generation time (the time between birth and sexual maturity) and the effective size of the breeding population (not all animals in a population are actively breeding at any given time). Also, for a mutation to affect an entire species, it must spread from the individual in which it occurs to the entire population. In the language of population genetics, it must become "fixed."

Neo-Darwinian population geneticists have incorporated these variables into standard formulas that estimate how long it takes for mutations to become fixed. A 2008 study used those formulas to calculate that two mutations in regulatory genes could become fixed in fruit flies in a few million years. In humans, however, which have much smaller effective breeding populations and longer generation times, the process would take more than 100 million years.[47]

Biologist Richard Sternberg has applied this analysis to cetaceans. Large mammals (such as the supposed ancestors of cetaceans) tend to have effective breeding population sizes comparable to that of humans, but modern whales reach maturity much faster, so their generation times are much shorter. Assuming a generation time of twenty-five years for humans and five years for the ancestors of cetaceans, Sternberg pointed out that fixing just two mutations in the latter would take millions of years longer than the time available in the fossil record.[48] So there isn't enough time to fix even two mutations, yet we need hundreds or even thousands of new mutations. Obviously, eight million years is not long enough to accumulate enough accidental mutations to turn a "walking whale" into a real whale—even if neo-Darwinian theory were right about the power of mutations (which it isn't).

It Gets Worse

In 2016, a team of paleontologists published a report of their discovery in Antarctica of a fossilized whale similar to *Basilosaurus*. The fossil occurred in rocks previously reported to be at least forty-nine million years old—older than some of the so-called "walking whales." This would reduce the time available for land-mammal-to-whale evolution from eight million years to practically no time at all—making the problem of whale evolution even worse.

Faced with this problem, the paleontologists who reported the discovery argued that the date of forty-nine million years "might be biased." They argued instead that a date no older than forty-six million years was "more consistent" with the fossil record of other whales.[49] But adjusting the date to be more consistent with the standard story isn't how empirical science is supposed to work.[50]

So "the sweetest series of transitional fossils an evolutionist could ever hope to find" is not so sweet after all. It quickly sours with a little additional digging.

With enough imagination anyone can invent a story about how land animals evolved into whales. But an imaginative story is not empirical science. When the materialistic story of whale evolution ignores inconvenient evidence, it is zombie science.

71. Dean Hamer and Peter Copeland, *The Science of Desire: The Search for the Gay Gene and the Biology of Behavior* (New York: Simon & Schuster, 1994).

72. Neal Risch, Elizabeth Squires-Wheeler, and Bronya J. B. Keats, "Male sexual orientation and genetic evidence," *Science* 262 (1993): 2063–2065. doi:10.1126/science.8266107. PMID:8266107.

73. George Rice, Carol Anderson, Neil Risch, and George Ebers, "Male homosexuality: Absence of linkage to microsatellite markers at Xq28," *Science* 284 (1999): 665–667. doi:10.1126/science.284.5414.665. PMID:10213693.

74. Alan R. Sanders, Eden R. Martin, Gary W. Beecham, S. Guo, Khytam Dawood, G. Rieger, Judith A. Badner, Elliot S. Gershon, R. S. Krishnappa, A. B. Kolundzija, J. Duan, P. V. Gejman, and J. Michael Bailey, "Genome-wide scan demonstrates significant linkage for male sexual orientation," *Psychological Medicine* 45 (2015): 1379–1388. doi:10.1017/S0033291714002451. PMID:25399360.

75. Tuck C. Ngun, Weilong Guo, Negar M. Ghahramani, Kajori Purkayastha, Daniel Conn, Francisco J. Sánchez, Sven Bocklandt, Michael Q. Zhang, Christina M. Ramírez, Matteo Pellegrini, and Eric Vilain, "PgmNr 95: A novel predictive model of sexual orientation using epigenetic markers," American Society for Human Genetics Annual Meeting, Session 27 (Baltimore, MD; October 8, 2015). https://ep70.eventpilotadmin.com/web/page.php?page=IntHtml&project=ASHG15&id=150123267.

76. Nalini Padmanabhan, "Epigenetic algorithm accurately predicts male sexual orientation," American Society of Human Genetics (October 8, 2015). http://www.ashg.org/press/201510-sexual-orientation.html.

77. John Greally, "Over-interpreted epigenetics study of the week," *Blog of the Center for Epigenomics at the Albert Einstein College of Medicine* (October 9, 2015). http://epgntxeinstein.tumblr.com/post/130812695958/over-interpreted-epigenetics-study-of-the-week-2.

78. Ed Yong, "No, scientists have not found the 'gay gene'," *The Atlantic* (October 10, 2015). http://www.theatlantic.com/science/archive/2015/10/no-scientists-have-not-found-the-gay-gene/410059/.

79. Dean H. Hamer, *The God Gene: How Faith Is Hardwired into Our Genes* (New York: Anchor Books, 2004).

80. John Horgan, "'Gene-whiz' science strikes again: Researchers discover a liberal gene," *Scientific American Blog Network* (October 29, 2010). http://blogs.scientificamerican.com/cross-check/gene-whiz-science-strikes-again-researchers-discover-a-liberal-gene/.

Chapter 5 (Pages 99–114)

1. Charles Darwin, *On the Origin of Species by Means of Natural Selection*, 1st ed. (London: John Murray, 1859), 179, 184.

2. Francis Darwin and A. C. Seward, eds., *More Letters of Charles Darwin* (London: John Murray, 1903), I:162. http://darwin-online.org.uk/content/frameset?pageseq=205&itemID=F1548.1&viewtype=side.

3. Philip D. Gingerich, Neil A. Wells, Donald E. Russell, and S. M. Ibrahim Shah, "Origin of whales in epicontinental remnant seas: New evidence from the early

Eocene of Pakistan," *Science* 220 (1983): 403–406. doi:10.1126/science.220.4595.403. PMID:17831411.

4. Percival Davis, Dean H. Kenyon, and Charles B. Thaxton, *Of Pandas and People: The Central Question of Biological Origins*, 2nd ed. (Dallas, TX: Haughton Publishing, 1993), 101–102.

5. J. G. M. Thewissen, S. Taseer Hussain, and Muhammad Arif, "Fossil evidence for the origin of aquatic locomotion in archaeocete whales," *Science* 263 (1994): 210–212. doi:10.1126/science.263.5144.210. PMID:17839179.

6. Philip D. Gingerich, S. Mahmood Raza, Muhammad Arif, Mohammad Anwar, and Xiaoyuan Zhou, "New whale from the Eocene of Pakistan and the origin of cetacean swimming," *Nature* 368 (1994): 844–847. doi:10.1038/368844a0.

7. Stephen Jay Gould, "Hooking Leviathan by its past," *Natural History* 103 (May 1994): 8–14.

8. Sunil Bajpai and J. G. M. Thewissen, "A new, diminutive whale from Kachchh (Gujarat, India) and its implications for locomotor evolution of cetaceans," *Current Science* (New Delhi) 79 (2000): 1478–1482.

9. J. G. M. Thewissen, Lisa Noelle Cooper, Mark T. Clementz, Sunil Bajpai, and Brahma N. Tiwari, "Whales originated from aquatic artiodactyls in the Eocene epoch of India," *Nature* 450 (2007): 1190–1194. doi:10.1038/nature06343. PMID:18097400.

10. Philip D. Gingerich, Munir ul-Haq, Wighart von Koenigswald, William J. Sanders, B. Holly Smith, and Iyad S. Zalmout, "New protocetid whale from the middle Eocene of Pakistan: Birth on land, precocial development, and sexual dimorphism," *PLoS One* 4 (2009): e4366. doi:10.1371/journal.pone.0004366. PMID:19194487.

11. Kevin Padian, "The tale of the whale," *Reports of the National Center for Science Education* 17:6 (1997): 26–27. http://ncse.com/rncse/17/6/tale-whale.

12. Gingerich, "New protocetid whale," 14.

13. J. G. M. Thewissen, *The Walking Whales: From Land to Water in Eight Million Years* (Berkeley: University of California Press, 2014), 169.

14. J. G. M. Thewissen and Sunil Bajpai, "Whale origins as a poster child for macroevolution," *BioScience* 15 (2001): 1037–1049. doi:10.1641/0006-3568(2001)051[1037:WOAAPC]2.0.CO;2.

15. Kate Wong, "The mammals that conquered the seas," pp. 182–191 in *Evolution: A Scientific American Reader* (Chicago: University of Chicago Press, 2006), 189.

16. Thewissen, "Whales originated from aquatic artiodactyls," 1190.

17. Everhard J. Slijper, *Whales*, trans. A. J. Pomerans, 2nd ed. (Ithaca, NY: Cornell University Press, 1962), 100–101, 108.

18. Frank E. Fish, John T. Beneski, and Darlene R. Ketten, "Examination of the three-dimensional geometry of cetacean flukes using computed tomography scans: Hydrodynamic implications," *Anatomical Record* 290 (2007): 614–623. doi:10.1002/ar.20546. PMID:17516428.

19. Slijper, *Whales*, 151.

20. Gregory S. Schorr, Erin A. Falcone, David J. Moretti, and Russel D. Andrews, "First long-term behavioral records from Cuvier's beaked whales (*Ziphius cavirostris*) reveal record-breaking dives," *PLoS One* 9 (2014): e92633. doi:10.1371/journal.pone.0092633. PMID:24670984.

21. Slijper, *Whales*, 139–140.

22. Richard E. Brown and James P. Butler, "The absolute necessity of chest-wall collapse during diving in breath-hold diving mammals," *Aquatic Mammals* 26 (2000): 26–32.

23. Sam H. Ridgway, B. L. Scronce, and John Kanwisher, "Respiration and deep diving in the bottlenose porpoise," *Science* 166 (1969): 1651–1654. doi:10.1126/science.166.3913.1651. PMID:5360592.

24. Konrad J. Falke, Roger D. Hill, Jesper Qvist, Robert C. Schneider, Michael Guppy, Graham C. Liggins, Peter W. Hochachka, Richard E. Elliott, and Warren M. Zapol, "Seal lungs collapse during free diving: Evidence from arterial nitrogen tensions," *Science* 229 (1985): 556–558. doi:10.1126/science.4023700. PMID:4023700.

25. Birgitte I. McDonald and Paul J. Ponganis, "Lung collapse in the diving sea lion: Hold the nitrogen and save the oxygen," *Biology Letters* 8 (2012): 1047–1049. doi:10.1098/rsbl.2012.0743. PMID:22993241.

26. Shawn R. Noren and Terrie M. Williams, "Body size and skeletal muscle myoglobin of cetaceans: Adaptations for maximizing dive duration," *Comparative Biochemistry and Physiology* A 126 (2000): 181–191. doi:10.1016/S1095-6433(00)00182-3. PMID:10936758.

27. Slijper, *Whales*, 133.

28. Per F. Scholander, "The master switch of life," *Scientific American* (December, 1963): 92–106.

29. Roger G. Spragg, Paul J. Ponganis, James J. Marsh, Gunnar A. Rau, and Wolfgang Bernhard, "Surfactant from diving aquatic mammals," *Journal of Applied Physiology* 96 (2004): 1626–1632. doi:10.1152/japplphysiol.00898.2003. PMID:14688033.

30. Natalie J. Miller, Anthony D. Postle, Sandra Orgeig, Grielof Koster, and Christopher B. Daniels, "The composition of pulmonary surfactant from diving mammals," *Respiratory Physiology and Neurobiology* 152 (2006): 152–168. doi:10.1016/j.resp.2005.08.001. PMID:16140043.

31. Sentiel A. Rommel, D. Ann Pabst, William A. McLellan, James G. Mead, and Charles W. Potter, "Anatomical evidence for a countercurrent heat exchanger associated with dolphin testes," *Anatomical Record* 232 (1992): 150–156. doi:10.1002/ar.1092320117. PMID:1536461.

32. Sentiel A. Rommel, D. Ann Pabst, and William A. McLellan, "Reproductive thermoregulation in marine mammals," *American Scientist* 86 (1998): 440–448. doi:10.1511/1998.5.440.

33. Slijper, Whales, 381–382.

34. Genevieve Johnson, Alexandros Frantzis, Chris Johnson, Voula Alexiadou, Sam H. Ridgway, and Peter T. Madsen, "Evidence that sperm whale (*Physeter macrocephalus*) calves suckle through their mouth," *Marine Mammal Science* 26 (2010): 990–996. doi:10.1111/j.1748-7692.2010.00385.x.

35. Slijper, *Whales*, 382–383, 386.

36. Thewissen, *Walking Whales*, 186–187.

37. Heinz-Georg Belting, Cooduvalli S. Shashikant, and Frank H. Ruddle, "Modification of expression and cis-regulation of *Hoxc8* in the evolution of diverged axial morphology," *Proceedings of the National Academy of Sciences USA* 95 (1998): 2355–2360. doi:10.1073/pnas.95.5.2355. PMID:9482889.

38. Cooduvalli S. Shashikant, Chang B. Kim, Marc A. Borbély, Wayne C. H. Wang, and Frank H. Ruddle, "Comparative studies on mammalian *Hoxc8* early enhancer sequence reveal a baleen whale-specific deletion of a cis-acting element," *Proceedings of the National Academy of Sciences USA* 95 (1998): 15446–15451. doi:10.1073/pnas.95.26.15446. PMID:9860988.

39. Lars Bejder and Brian K. Hall, "Limbs in whales and limblessness in other vertebrates: Mechanisms of evolutionary and developmental transformation and loss," *Evolution and Development* 4 (2002): 445–458. doi:10.1046/j.1525-142X.2002.02033.x. PMID:12492145.

40. Robert W. Meredith, John Gatesy, Joyce Cheng and Mark S. Springer, "Pseudogenization of the tooth gene enamelysin (*MMP20*) in the common ancestor of extant baleen whales," *Proceedings of the Royal Society of London B* 278 (2011): 993–1002. doi:10.1098/rspb.2010.1280. PMID:20861053.

41. Ping Feng, Jinsong Zheng, Stephen J Rossiter, Ding Wang, and Huabin Zhao, "Massive losses of taste receptor genes in toothed and baleen whales," *Genome Biology and Evolution* 6 (2014): 1254–1265. doi:10.1093/gbe/evu095. PMID:24803572.

42. Shixia Xu, Yuan Chen, Yuefeng Cheng, Dan Yang, Xuming Zhou, Junxiao Xu, Kaiya Zhou, and Guang Yang, "Positive selection at the ASPM gene coincides with brain size enlargements in cetaceans," *Proceedings of the Royal Society of London B* 279 (2012): 4433–4440. doi:10.1098/rspb.2012.1729. PMID:22977148.

43. Stephen H. Montgomery, Nicholas I. Mundy, and Robert A. Barton, "*ASPM* and mammalian brain evolution: A case study in the difficulty in making macroevolutionary inferences about gene-phenotype associations," *Proceedings of the Royal Society of London B* 281 (2014): 20131743. doi:10.1098/rspb.2013.1743. PMID:24452019.

44. Morris Agaba, Edson Ishengoma, Webb C. Miller, Barbara C. McGrath, Chelsea N. Hudson, Oscar C. Bedoya Reina, Aakrosh Ratan, Rico Burhans, Rayan Chikhi, Paul Medvedev, Craig A. Praul, Lan Wu-Cavener, Brendan Wood, Heather Robertson, Linda Penfold, and Douglas R. Cavener, "Giraffe genome sequence reveals clues to its unique morphology and physiology," *Nature Communications* 7 (2016): 11519. doi:10.1038/NCOMMS11519. PMID:27187213.

45. Wolf-Ekkehard Lönnig, *The Evolution of the Long-Necked Giraffe (Giraffa camelopardalis L.): What do we really know? Testing the Theories of Gradualism, Macromutation, and Intelligent Design* (Münster, Germany:Verlagshaus Monsenstein und Vannerdat OHG, 2011).

46. John W. Drake, Brian Charlesworth, Deborah Charlesworth, and James F. Crow, "Rates of spontaneous mutation," *Genetics* 148 (1998): 1667–1686. PMID:9560386.

47. Rick Durrett and Deena Schmidt, "Waiting for two mutations: With applications to regulatory sequence evolution and the limits of Darwinian evolution," *Genetics* 180 (2008): 1501–1509. doi:10.1534/genetics.107.082610. PMID:18791261.

48. Richard V. Sternberg, "The problem of whale origins," debate with Stephen C. Meyer, Donald R. Prothero, and Michael Shermer at Saban Theater, Beverly Hills, CA (November 30, 2009), 36:50–50:20. https://www.youtube.com/watch?v=lzwHqqMMSaU.

49. Mónica R. Buono, Marta S. Fernández, Marcelo A. Reguero, Sergio A. Marenssi, Sergio N. Santillana, and Thomas Mörs, "Eocene Basilosaurid Whales from the La Meseta

Formation, Marambio (Seymour) Island, Antarctica," *Ameghiniana* 53 (2016): 296–315 doi:10.5710/AMGH.02.02.2016.2922.

49. "An unbearable rush: Antarctic whale fossil poses a challenge to evolution that won't go away," *Evolution News & Views* (November 16, 2016). http://www.evolutionnews.org/2016/11/an_unbearable_r_1103292.html.

Chapter 6 (Pages 115–130)

1. Charles R. Darwin, *On the Origin of Species by Means of Natural Selection*, 1st ed. (London: John Murray, 1859), 168, 455–456.

2. Ibid., 451–452.

3. Charles R. Darwin, *The Descent of Man and Selection in Relation to Sex* (London: John Murray, 1871), I:17–18, 32.

4. Ibid., 27.

5. Richard J. A. Berry, "The true caecal apex, or the vermiform appendix: Its minute and comparative anatomy," *Journal of Anatomy and Physiology* 35 (1900): 83–100. PMID:17232459.

6. Pedro Gorgollón, "The normal human appendix: A light and electron microscopic study," *Journal of Anatomy* 126 (1978): 87–101. PMID:649505.

7. Dale E. Bockman, "Functional histology of appendix," *Archivum Histologicum Japonicum* 46 (1983): 271–292. doi:10.1679/aohc.46.271. PMID:6357136.

8. Kohtaro Fujihashi, Jerry R. McGhee, Cummins Lue, Kenneth W. Beagley, Tetsuya Taga, Toshio Hirano, Tadamitsu Kishimoto, Jiri Mestecky, and Hiroshi Kiyono, "Human appendix B cells naturally express receptors for and respond to interleukin 6 with selective IgA1 and IgA2 synthesis," *Journal of Clinical Investigation* 88 (1991): 248–252. doi:10.1172/JCI115284. PMID:2056119.

9. Giacomo Azzali, "Three-dimensional and ultrastructural aspects of the lymphatic vascularization of the vermiform appendix," *Journal of Submicroscopic Cytology and Pathology* 30 (1998): 545–553. PMID:9851063.

10. Aliya Zahid, "The vermiform appendix: Not a useless organ," *Journal of the College of Physicians and Surgeons—Pakistan* 14 (2004): 256–258. PMID:15228837.

11. R. Randal Bollinger, Andrew S. Barbas, Errol L. Bush, Shu S. Lin, and William Parker, "Biofilms in the large bowel suggest an apparent function of the human vermiform appendix," *Journal of Theoretical Biology* 249 (2007): 826–831. doi:10.1016/j.jtbi.2007.08.032. PMID:17936308.

12. Gene Y. Im, Rani J. Modayil, Cheng T. Lin, Steven J. Geier, Douglas S. Katz, Martin Feuerman, and James H. Grendell, "The appendix may protect against *Clostridium difficile* recurrence," *Clinical Gastroenterology and Hepatology* 9 (2011): 1072–1077. doi:10.1016/j.cgh.2011.06.006. PMID:21699818.

13. Michel Laurin, Mary Lou Everett, and William Parker, "The cecal appendix: One more immune component with a function disturbed by post-industrial culture," *Anatomical Record* 294 (2011): 567–579. doi:10.1002/ar.21357. PMID:21370495.

14. Heather F. Smith, William Parker, Sanet H. Kotzé, and Michel Laurin, "Morphological evolution of the mammalian cecum and cecal appendix," *Comptes Rendus Palevol* 16 (2017): 39–57. doi:10.1016/j.crpv.2016.06.001.