No Change, No Fowl: A Theory for the Birds

By Larry Zaleski

Larry Zaleski

Larry Zaleski was born and raised in southern New Jersey. He grew up a "free range kid," which allowed him to become familiar with the farms, fields, woods, streams, and wildlife of his native state.

Larry holds BS and MS degrees in Biology from Northern Arizona University. He has worked primarily within the federal government in biologically oriented programs within the Departments of Commerce (as a high-seas biological technician), Interior (with the U.S. Fish and Wildlife Service Division of Law Enforcement), and Agriculture (as an inspector, officer, and trainer).

For the past 30 years Larry has held various training posts within USDA's Animal and Plant Health Inspection Service at their Professional Development Center. These include instructional designer, project leader, supervisor, and senior training specialist. Larry has written technical manuals, and managed, designed, developed, and delivered elearning and classroom courses for a wide range of scientific, technical, and managerial topics.

He retired in October 2015, and now resides in Hagerstown, Maryland, where he spends his time with his wife, Mary, birding, studying, and writing.

This paper was presented to the Torch Club of Hagerstown, MD on October 21, 2014.

Even a casual observer cannot fail to notice that there are a bewildering number of living things. And soon that same observer unthinkingly, automatically begins to split and lump this cacophony, organizing it into categories large and small, first into plants and animals, and then finer groupings. Virtually everyone, even primitive people, recognizes the similarities and differences. Biologists have constructed elaborate assemblages, recently made more precise through genetic analysis.

The question is, how did these groupings arise? Were they created as is, forever unchanging, or are they derived, dynamic, and continually in flux?

Until 156 years ago, the answer was thought settled—life was first created in its present form and is unchanging. No other explanation was countenanced. But naturalists suspected differently. They noticed that some species were visually identical and could only be told apart by their behavior. And they noticed that most creatures varied along a gradient from more similar to less similar.

Fossils obtained from younger surface rock appeared much like living species, while those from progressively older, deeper rock were increasingly different. Near-surface species soon disappeared, replaced by species that no longer existed. It appeared that species changed over time; they evolved. But no one knew how or why.

Once the age of discovery opened the world further, many observations and conclusions were recorded and circulated, enabling two naturalists, Charles Robert Darwin and Alfred Russell Wallace, through a combination of academic study and personal observation, to collect evidence, develop concepts, and propose mechanisms explaining evolution. Darwin and Wallace were the first to present a plausible natural mechanism to drive the process—which they named natural selection—and the evidence to support it. They elevated evolution from a hypothesis to a theory, the highest form of scientific understanding.

Since then, biologists have incorporated Mendelian genetics and expanded Darwin's concept into what is called the modern synthesis. Together, these ideas have become the unifying principles of the life sciences, and have led the way for analogous discoveries in geology and astronomy.

Reading newspapers and the Internet, though, you might think that there is controversy. The theory of evolution seems to have an impressive challenger: "intelligent design" (ID). Biologists, however, remain confident about the modern Darwinian synthesis; furthermore, they have excellent reasons to do so.

What Is Evolution?

Misconceptions concerning the theory of evolution abound. In its authentic form, it contains six components (Coyne; Mayer):

The first is ***evolution itself***. Evolution is genetic change in a population over time, resulting in physical and metabolic shifts.

The second is ***gradualism***. Gradualism means that change occurs not suddenly, but over many generations through a series of small modifications.

The third is ***speciation***. This is the splitting of species into different groups. Typically, speciation occurs when groups become geographically isolated for generations and then diverge through natural selection and genetic drift. The changes accumulate, so when they again come into contact, they are unable to interbreed.

Fourth is ***common ancestry***. Looking back in time, all species and grouping of species, such as dogs and bears, eventually join at a common ancestral species. Common descent is a consequence of splitting, resulting in a nested arrangement such that species with a recent common ancestor share many traits. This is why we recognize house cats, lions, and the fossils of sabertoothed tigers all as "cats."

Fifth is ***natural selection***, a filtration process that tinkers with existing genetic traits. Individuals differ in their genetic makeup (differences arising from mutations and the mixing of genes during sexual reproduction), causing physical variation, which in turn affects each individual's ability to survive and reproduce. Individuals who leave more offspring also leave more genes in the next generation; the process results in species that are well adapted to their habitat. They are not *perfectly* adapted, however, because natural selection is constrained by the organism's evolutionary history; it is forced to work with what it has. Natural selection does not cause mutations or variations. It merely reacts to them.

Over time, natural selection makes a species fitter for its environment than it was before, but not the fittest possible. Because of its "make do" character, natural selection is not a master engineer; it does not plan or design from scratch. It only adjusts—hence every organism produced is flawed.

Since natural selection cannot achieve perfection, species often fail. We call their failure extinction (a hallmark of tinkering, not of design).

Lastly, natural selection also *prevents* change. When genes are highly adaptive, individuals that deviate tend to be eliminated. Such "stabilization" has two outcomes. First, it causes some well-adapted groups, such as clams, to remain outwardly unchanged for hundreds of millions of years. Second, it causes metabolically critical genes originating earlier in evolution to be present in subsequent species from that point on.

Individuals who leave more offspring also leave more genes in the next generation; the process results in species that are well adapted to their habitat.

The sixth and final component is ***nonselective evolutionary change***, random change in the proportion of genes, brought on by chance, called "genetic drift" (Mayr). Genetic drift is common in small populations where accidents have disproportionate impact. While less important than natural selection, genetic drift can result in unusual traits becoming common within a group, such as blue eyes or blond hair in Scandinavians.

Unfortunately, through ignorance or zeal to persuade, both advocates and opponents of evolution sometimes modify or eliminate one or more of the above components, resulting in personalized and flawed versions that only superficially resemble evolutionary theory. The accuracy of any portrayal of evolution depends on fidelity to these six components.

The Evidence for Evolution

Four lines of evidence constitute the main support for the theory of evolution: the fossil record, transitional forms, vestigial structures, and biogeography.

The Fossil Record

The most compelling evidence for evolution comes from the fossils found in sedimentary rock—rock that has formed in layers, called strata, one atop the other. Because the layers are sequential, they contain a continuous, if necessarily imperfect record of the life that existed at the time that the strata originated. In addition, the chemistry of the strata enables geochemists to infer the physical and chemical conditions under which the strata formed.

The fossil record shows that life has changed dramatically. The earliest fossils consist of bacterialike organisms called the Archaea, which appeared more than 3.5 billion years ago. The Archaea are prokaryotic (lack a nucleus or other membrane-bound organelles) anaerobic (have sulfur-based metabolisms that do not use oxygen) extremophiles (can survive extreme environments such as boiling water).

Cyanobacteria (blue-green algae) appeared later, roughly 2.7 billion years ago (University of California Museum

of Paleontology). They did not displace the Archaea, but lived beside them. Cyanobacteria could photosynthesize, producing oxygen as a waste product, which they pumped into the sea (Biello). But the oxygen was quickly removed by chemical reaction with the iron that was dissolved in the oceans and soils, causing the oceans to rust ("Great Oxygen Event"). The oxidized iron precipitated out and sank to the bottom, trapping the iron in banded sediments still visible today ("Banded iron formation"). After 300 million years of rusting, the iron was nearly used up, allowing free oxygen to accumulate. This is called the "Great Oxygen Event" (Biello; "Great Oxygen Event").

In this way, cyanobacteria became the unwitting architects of the earth's atmosphere. Eventually, they were able to convert the chemistry of the ocean and atmosphere from reducing to oxidizing, changing the biodiversity of life on earth (Coyne; Mayr).

Once the oxygen levels reached about 1.3 percent, *oxygen metabolism* and *eukaryotic cells* (cells with a nucleus and membrane-bound organelles, like those in our own bodies) became possible (Gilbert). Oxygen metabolism is 15 to 19 times more efficient than anaerobic metabolism ("Cellular respiration"), allowing greater power output and more complex structures.

The first eukaryotic cell appeared about 2.1 billion years ago (Simpson), setting the stage for the development of metazoan animals and vascular plants (animals and plants with cells that differentiate into tissues). The first record of multicellular animals consists of the *Ediacarans* (resembling jellyfish and segmented worms). Most species at this time were soft-bodied, so they left few fossils. However, the development of the eukaryotic cell followed by that of organisms composed of tissues prepared life for what is called the Cambrian explosion.

At this point, about 550 million years ago, evolution proceeded relatively rapidly. Over the next 53 million years, all of the main lines of animal types whose descendants are alive today appeared in the record.

Like reptiles, archaeopteryx had teeth, an unfused lizardlike tail, and claws on each wing, and lacked a deep keel for flight muscle attachment.

Although the exact reasons for the Cambrian explosion are still debated, a combination of factors likely affected the rapid development: increases in the oxygen level, the formation of the ozone layer (shielding life from ultraviolet light), increase in calcium concentrations caused by heavy volcanism from the expanding mid-ocean ridge (releasing minerals, thus allowing the development of skeletons), development of regulatory genes directing tissue differentiation, development of predators resulting in an arms race, development of eyes, and movement into unoccupied ecological niches, including colonization of the land thanks to the new ozone layer ("Cambrian explosion").

From this time forward, new species of animals and plants appeared at a regular pace. The Wikipedia article "Timeline for the history of life" charts earth's increasing diversity, from the emergence of bilaterians (life forms with a front and a back) 550 million years ago (MYA) to fish and proto-amphibians (500 MYA), landplants (475 MYA), insects and seeds (400 MYA), and reptiles (300 MYA), on up to primates (60 MYA), the great apes (20 MYA), the genus Homo (2.5) MYA, and, relatively recently, anatomically modern humans (200,000 years ago).

The fossil record provides unmistakable evidence for macro-evolution. Conversely, there is *no* evidence that species and higher taxa all appeared suddenly or remain unchanged (Coyne). That nearly all species in the fossil record are extinct strongly suggests that life developed by an *un*-intelligent design, by what we call natural selection.

Transitional Forms

One consequence of gradual common descent is the formation of transitional forms. Species do not jump fully formed to the next level. They develop gradually, at some point spanning the gap, having characteristics of both ancestral and descendant species. Two examples are the archaeopteryx (transitional between feathered dinosaurs and birds) and the monotremes (transitional between reptiles and mammals).

Archaeopteryx was a pigeon-sized, reptilian-like bird that lived about 150 million years ago. Like reptiles, archaeopteryx had teeth, an unfused lizardlike tail, and claws on each wing, and lacked a deep keel for flight muscle attachment. But like birds, it had a beak, a wishbone, asymmetric flight feathers with veins and hooks, and could at least glide and maybe fly. Birds, even today, have scales around their eyes and on their legs, a reptilian legacy.

Monotremes are egg-laying mammals. Like reptiles, monotremes lack a corpus collosum linking the two hemispheres of the brain, have a cloaca (a single opening for defecation, urination, and reproduction), and they *lay eggs*. But like mammals, the monotremes are warm-blooded, have hair, produce milk in mammary glands to feed their young, and have mammal-like jawbones. Several species still survive, including the duck-billed platypus and four species of spiny anteater.

Transitional forms show the progression from one form to another. They show refashioning of existing traits into something new—scales refashioned into hair or feathers, or feathers (which evolved before flight) refashioned for gliding and flying. Transitional forms show adaptation, not perfection, and they often go extinct.

Vestigial Structures

Another consequence of gradual change is the presence of vestiges: features that have lost their function, but still exist. Vestiges are genetically determined remnants of an organism's evolutionary past. Three examples are the wings of flightless birds, the eyes of cavefish and moles, and pseudogenes.

Flightless birds such as the ostrich, penguin, and kiwi all have remnant wings no longer used for flight. Yet, in most cases, their wings still function in some way. The ostrich uses its wings for balance while running, and the penguin to swim. In all cases, feathers still provide insulation and protection from the sun, but no longer flight propulsion. And their wings have the same bones as flying species, regardless (Coyne), all evidence against the intelligent design defenders' claim of irreducible complexity.

Similarly, cavefish and moles have eyes that have lost their function. These animals have adapted to dark environments where vision is unnecessary. Either because they are unprotected by stabilizing selection or actively de-selected, their eyes have degenerated, resulting in mere remnants.

Pseudogenes are "fossil" genes, dysfunctional genes that were once useful but are no longer intact or expressed, such as the gene for making vitamin C in humans and the gene for making hemoglobin in icefish.

Vestiges are genetically determined remnants of an organism's evolutionary past. Three examples are the wings of flightless birds, the eyes of cavefish and moles, and pseudogenes.

Nearly all mammals can make vitamin C, which is essential for proper metabolism. However, primates (including humans), fruit bats, and guinea pigs must obtain vitamin C from their food because they cannot synthesize it. This is why early sailors who lacked a proper diet developed scurvy. Humans do, however, still carry the gene to make vitamin C; unfortunately, we are missing a single nucleotide in a separate activation gene, rendering the vitamin C gene useless. This same nucleotide is missing in all primates, so is part of our evolutionary heritage (Coyne).

Icefish are the only known vertebrates to lack red blood cells. They have lost one of the two genes for hemoglobin (which carries oxygen for respiration) and retain a damaged version of the other (Brown). Icefish can function without hemoglobin because they live in the southern oceans in water that is minus 2 degrees Celsius (below the freezing point of pure water). Since cold water carries more oxygen than warm water, icefish can still respire.

Because evolution involves a series of imperfect improvements that were tacked onto existing structures, rather than designed, the outcomes are often messy. Consequently, our bodies and our genomes are littered with vestiges and broken genes—our fossils within.

Biogeography

Biogeography is the study of the past and present distribution of the world's species. Island biogeography provides further evidence of natural selection at work.

Volcanic oceanic islands, such as the Galapagos and Hawaiians, are both geologically young and geographically remote. Accordingly, species on these islands either had to arrive after the island's formation (or be created in place). Because the islands are remote, colonizers had to be capable of long distance dispersal to drift, swim, or fly there. Such colonizations are accidental and rare.

Oceanic islands are as notable for the species they lack as for those they have. Their native species typically include plants, birds, and insects. Missing are land mammals, reptiles, amphibians, and fresh water fish, which cannot disperse there. In contrast, continental islands (those once connected to continents) have the full range of species. This pattern is consistent with accidental dispersal of mobile species to oceanic islands.

Continued on page 25

Continued from page 20

Oceanic islands also contain many unique species because early colonizers found environments with many unoccupied habitats that lacked competitors and predators. As a result, they were able to diversify and occupy the open habitats.

Consequently, we see adaptive radiations of related organisms—one or two species splitting into many. Examples include Darwin's famous finches on the Galapagos and the Hawaiian honeycreepers, both derived from finches. The woodpecker finch on the Galapagos, for example, has filled the ecological role of continental woodpeckers, but does so using a twig to pry insects from trees. And without the threat of predators, some birds have lost their formerly life-saving adaptation of flight, which is energetically costly if not needed.

These evolutionary patterns tend to repeat, but with different species in each location. The pattern does not resemble the patterns expected from creation in place or design, which would have more complete distributions of creatures. But it does resemble what you would expect from accidental colonization followed by evolutionary adaptations.

Intelligent Design

ID is often presented as a scientific alternative to the theory of evolution. However, this claim can be disputed on several counts.

First, the primary ID text, *Of Pandas and People* (Davis and Kenyon), was shown to misrepresent its scientific standing during testimony presented at the Dover vs. Kitsmiller trial in 2005. A comparison of the final version of the text to an earlier 1987 version revealed that the term "creationism" had been systematically replaced with the words "intelligent design" to hide the book's roots in religious belief. The term "intelligent design" is merely a synonym for "creationism," and the concept is based on Bible stories, not physical evidence (Biever; Forrest).

Second, ID does not specify the designer or how the designer operates, so it cannot generate testable expectations. Un-testable and hence un-falsifiable, it will forever remain speculation.

Third, the papers published by the ID community lack credibility (Gamble). In general, they attack evolution by focusing on gaps in the scientific knowledge (God of the gaps arguments), while failing to present evidence directly supporting ID itself. Most are little more than editorials or are published in philosophical journals. And a surprising (or unsurprising) number are published by non-biologists who are not expert in the field.

Finally, ID's main argument, that life is irreducibly complex, is unsupported by evidence. The alleged examples of irreducible complexity such as the flagellum (Miller), the eye (Mayr), and blood clotting (Jiang) have all been falsified.

All lines of evidence support the concept of an evolved living world. Evolution explains the fossil record, transitional forms, vestigial structures, island biogeography, and other lines of evidence too numerous to include here.

In contrast, ID fails on all counts. A religious concept, un-supported by evidence and un-testable, its alleged examples of irreducible complexity have been falsified. Consequently, ID does not qualify as a scientific theory. Evolution does.

The publication of this article is funded by The Torch Foundation

Works Cited

"Banded iron formation." Wikipedia. Web.

Biello, David. "The origin of oxygen in the earth's atmosphere." *Scientific American*. 19 August 2009. Web.

Biever, Celeste. "Book thrown at proponents of Intelligent Design." *New Scientist: Science and Society*. 6 October 2005. Web.

Brown, Daniel D. "Adaptation of the week: Channichthyidae Icefish Blood and Antifreeze." *Biochemical Soul*. Web.

"Cambrian explosion." Wikipedia. Web.

"Cellular respiration." Wikipedia. Web.

Coyne, Jerry A. *Why Evolution Is True*. NY: Penguin, 2009. Print.

"Cyanobacteria." Wikipedia. Web.

Davis, Percival, and Kenyon, Dean H. *Of Pandas and People: The Central Question of Biological Origins*. 2nd ed. Richardson, TX: Haughton, 1993. Print.

Forrest, Barbara. "My role in Kitzmiller vs Dover." National Center for Science Education, 2006. Web.

Gamble, David. "Claims of Peer Review for Intelligent Design examined... and debunked." Skeptical Science. 7 October 2012. Web.

Gilbert, D.L. *Oxygen and Living Processes: An Interdisciplinary Approach*. New York, Heidelberg, Berlin: Springer-Verlag, 1981. Print.

"Great Oxygen Event." Wikipedia. Web.

Jiang, Yong and Doolittle, Russell F. "The evolution of vertebrate blood coagulation as viewed from a comparison of puffer fish and sea squirt genomes." *Proceedings of the National Academy of Sciences of the United States of America* 100:13 (2003), 7527–7532. Web.

Mayr, Ernst. *What Evolution Is*. NY: Basic Books, 2001. Print.

Miller, Kenneth R. "The Flagellum Unspun: The Collapse of 'Irreducible Complexity'." Web.

Simpson, Dave. "Geologic Time: The Story of a Changing Earth: The Proterozoic." Smithsonian National Museum of Natural History. Web.

"Timeline of the evolutionary history for life." Wikipedia. Web.

University of California Museum of Paleontology. "Introduction to Cyanobacteria: Architects of the earth's atmosphere." Web.