The Conservancy Corner

The Theory of Natural Selection
Part 1 of 3: So Simple an Idea
By

Dick Byers

On November 24, we will celebrate the 150th anniversary of the publication of the "Origin of Species," Charles Darwin's time tested theory of natural selection. When I first read about this theory in my early teens it seemed so simple and made so much sense that I wondered why anyone hadn't thought of it before Darwin. Even Thomas Henry Huxley, Darwin's greatest supporter, asked himself why he hadn't thought of it. Evolution explains everything in nature so easily, so the lack of belief of something with so firm and simple a foundation is puzzling. I blame it mostly on a lack of education. The majority of people who say they don't believe in natural selection usually don't have the faintest idea what the theory is, or how it works because they were never taught this theory in the public schools. While it's legal to teach that organisms evolve, most biology teachers avoid the subject. I will attempt, in two essays, to spell out the basic tenets of this theory for those who do not know.

Darwin's theory rests on the fact that all individuals of a species are different, meaning none of the individuals of any specific group are exactly alike. Humans are probably a good example for those of you who are not nature-oriented. Look at the enormous differences from person to person. While we are all human, you can easily pick a friend of yours out of a crowd based just on your friend's unique traits or even by the sound of his or her voice. Many people can be recognized by their gait alone. Identical twins have their differences too. Just ask them. All of us are unique individuals. These differences hold true for every species of animal and plant on the planet, as any taxonomist will tell you. Even white laboratory mice are all distinct, highly variable individuals. Darwin drew a conclusion from these observations: All species show extreme variation among its individual members.

Darwin also noticed that all species produce many more offspring than can possibly survive. This is extremely well documented. Fish lay thousands of eggs. Amphibians lay hundreds of eggs. Plants produce millions of seeds and I don't have to elaborate on the reproductive potential of insects. Even birds and mammals produce far more offspring than can possibly survive. Take your common backyard robin. They normally lay 4 eggs in the nest, called a "clutch," and usually raise three "clutches" or broods a season. That's a total of 12 young. If we assume all 12 survive giving us six pairs the following year who all raise 12 young, it does not take much arithmetic to see that in 5 years, assuming 100% survival, you will have over 15,000 robins in your neighborhood just from that original single pair. Of course, that doesn't happen. The robin population in your neighborhood tends to stay about the same year after year for many reasons. The hazards young birds face are enormous. The local predators, dogs, cats, hawks, snakes, etc. kill quite a few. Cold rains may cause hypothermia of the nestlings. Disease takes a toll. Drought might reduce the food supply and some will starve. Research has shown that in most bird populations, 80 to 90% of the year's hatchlings do not survive to adulthood and that's pretty close to the truth for most wildlife populations. From these facts, Darwin drew a conclusion: There must be a

struggle for survival since not all the young that are produced can possibly survive. He devoted all of chapter three to this principle.

Darwin recognized, as I'm sure everybody has, that environments and living conditions constantly change. Nothing in this world is static. Animals and plants must adapt to constant new conditions or perish. As conditions change, forcing animals to adapt, you have only to remember that every animal is totally different than the other members of its species, and ask yourself which ones among that vast range of differences will have the best chance of surviving in the struggle for existence? I think you'll conclude it will be the individuals who by chance have the characteristics or variations that fit them to the new conditions. The survivors were born that way – just lucky enough to inherit the right traits. They didn't become that way in their life time. The mammal born with the thickest fur has the best chance of surviving an unusually cold winter. That same variation, thick fur in a warm climate, eliminates that trait from the population because of over- heating and hyperthermia. What works in one environment may be detrimental in another environment. Nature only selects what works. Any trait that gives an animal just a slight advantage over its competitors has a better chance of surviving and living to reproduce to pass that trait onto the next generation. The new generation will also vary and nature will choose who among them is best equipped for survival. For this reason Darwin called his theory natural selection. Nature selects the traits that adapt the animals for whatever conditions exist at the time. This is evolution theory in a nutshell. Natural selection explains how animals and plants become adapted to changing conditions. Herbert Spencer called it the survival of the fittest, which is a bit misleading, but I'll discuss that later.

In summary, all animals within a species are totally different. They reproduce in huge numbers, far more than can possibly survive. There is a struggle for existence, and in that struggle, the individuals who have the characteristics that are best for coping with the adverse conditions of the environment have the greatest chance of living to reproductive age and passing those traits on to the next generation. The best adapted survive. This idea works, verified thousands of times by observation and experiment.

Since this theory depends on the wide range of existing traits or great variety of individuals of each species, the most frequent question Darwin was asked is what causes variation? Darwin didn't know because the answer lies in the science of genetics, which wouldn't become publicly known until eighteen years after Darwin's death. To really understand evolution, a knowledge of heredity is essential to see exactly how nature chooses what genes will survive or be passed on. Many people have the misconception that a gene mutation could transform an animal from one form to another. That's ridiculous. No single gene has such broad power. Each gene controls just one minute trait. All mutations do is provide new genes for natural selection to act upon. And thanks to the cosmic radiation that slips through our ozone shield, mutations occur frequently, in any cell of any plant or animal. Mutations are not rare events, but the only place that mutations can make any difference is in the reproductive cells so they can be passed on in the eggs and sperm. A mutation occurring in one of your skin cells as you read this will make no difference to you or anyone.

This explanation is still incomplete. Part 2 will provide some examples of the selection process .

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Darwin's Theory of Natural Selection

Part 2 of 3: Mechanics of Selection

By

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In Part One I outlined the basic tenets of Darwin's theory. This second essay will try to illuminate those principles with some examples.

In the Canary Islands there's a species of bird that lays, on average, four eggs in the nest. The same species on mainland Europe lays, on average, six eggs in the nest. Why the difference? Researchers found that the birds in the Canary Islands have fewer predators than their mainland cousins, and therefore need not expend the extra energy producing more eggs than necessary. Four eggs will maintain the population at a very constant level, whereas mainland birds must lay six to maintain their population. The question that comes to mind, of course, is how do the birds know this and behave appropriately? Well, they don't know it. Birds just do what comes naturally. Apply the theory as I stated in the first essay by thinking in terms of what variations are possible. There will be a small percentage of birds who don't stick to the four or six egg clutch in each population. The number of eggs produced by this species ranges from 2 to 10, with the vast majority laying an average of 4 and 6 in respective populations. Birds producing clutches of six on average survived best on the mainland and those on the Canary Islands that survived best had clutches of four. Birds that laid up to 10 eggs or more eggs than the necessary two or six to beat the mortality rate might boost the population occasionally, but in years of drought when food production might be below par, their nests stood a greater chance of failure than those that laid fewer eggs. With more mouths to feed and less food available the entire brood would be threatened. On the other hand, birds laying fewer eggs than are needed to assure at least enough will survive to **replace the parents** are courting extinction. If four young eventually die at the hands of predators from each nest, then the parents must lay at least 6 eggs on average (replacement of the parents) to maintain the population and not go extinct. In both situations described, over long periods of time, nature selected for survival the birds that naturally laid the best number to maintain a constant population, four on the islands and six on the mainland. Should the situation change, like the accidental introduction of more bird predators to the islands, you can predict the clutch size of the island birds will go up. If the adaptive change isn't rapid enough, the birds may be extirpated there.

Textbooks usually explain how the giraffe neck lengthened, but fail to point out how it illustrates one of the fundamental driving forces in natural selection. Variation in the height of today's giraffes is significant, ranging from 10 to 22 feet with an average of 16 and is probably still increasing. Giraffes are herbivores in a climate of periodic drought. During the dry season only the deep rooted plants (trees and large shrubs) maintain their leaves. All other vegetation drops their leaves until the rains come.

Obviously there is more food available to the taller animals during the dry season. They can simply reach the higher leaves on the trees and in the course of many millennia, more of the taller animals with this advantage survived. In the Canary island egg-laying example, it was environmental factors driving the selection. In the case of the giraffes, note that it is competition among individuals driving the selection. The environment does not necessarily have to change for evolution to occur. Competition among members of the same species for scarce resources is often the main driving force in evolution. Incidentally, giraffes have the same number of neck vertebrae as any other vertebrate – seven. The bones are simply longer, a common variation in the bones of all vertebrates.

Animal breeders use Darwin's theory to produce new strains of domestic animals and plants. My spaniels have floppy ears, a trait that doesn't survive in nature, but one that some humans like. Since we protect our domestic animals from most of the eliminative forces of nature we can choose whatever traits we want to survive from the natural variation that exists in the population. We produced Basset hounds by artificially selecting the longest bodied and shortest legged dogs for breeding. The idea was to slow down the Basset hounds so they wouldn't get too far ahead of the hunters, but in nature, Bassett hounds could never survive. By breeders using artificial, rather than natural selection, we can produce almost any kind of characteristic we want – like chickens that can lay eggs 300 eggs a year. We've been doing this since the invention of agriculture 10,000 years ago.

In these examples I have been talking about changing the traits of the same species. All the different kinds of dogs are still a single interbreeding species. Natural selection easily explains how animals adapt, but does it actually produce new species? We'll tackle that question in part 3 of this essay along with some other misconceptions about evolution that should be mentioned.

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Darwin's theory of natural selection

Part 3 of 3: Myths

By

Dick Byers

In the previous essay I supplied two examples of natural selection at work to illustrate how animals adapt to environmental influences and competition among individuals of the same species. While my illustrations explain how animals adapt, are they also responsible for the creation of new species? Let us first raise the question of time. How long does it take for a new trait to evolve? I'll begin with the individual traits I've been talking about, traits that adapt the animal to a new condition, but that do not change the actual species. How long does it take for simple adaptive changes to appear? You might be surprised that some occur in a span of just a few years. The best documentation we have of this in the case of vertebrates is the study done by Peter and Rosemary Grant on the Galapagos finches. They found changes in the average shape and length of the bill in several species in 2-3 years

("Evolutionary Dynamics of a Natural Population", University of Chicago Press, 1989). Jonathan Weiner made this 350-page scientific paper intelligent to the general public in his book entitled "The Beak of the Finch, A Story of Evolution in Our Time." That well written treatise will enlighten anyone on how those birds changed in so short a period.

Likewise, insect populations can change character in just a few generations. Raise mosquitoes in barrels of rain water and subject them to a pesticide. The first spraying will kill 99.9% of the population, but there are always a few survivors who were lucky enough to already have some sort of immunity to the poison. Allowing them to breed and spraying the new generation with the pesticide will likely kill 85% of the population allowing the remaining 15% to breed. You can see by this process it will not take many generations before we have a population that is 98% immune to the poison. The poison will always kill a few because some will be unlucky enough not to inherit the immunity, but, within just a few generations we'll have a population of resistant mosquitoes that didn't exist before. This, in fact, is a valid argument against chemical control of insects. All pesticides do is select the most poison resistant insects for survival.

Now let's increase these small changes over a much longer period of time, say a few million years. Is it not sensible to think that the accumulation of these small changes over longer periods of time will produce new species? Obviously we cannot live long enough to actually witness it, so where do we go for proof? There are vast sources, too much to discuss in one essay, but there is convincing evidence from the fossil record, embryology, comparative anatomy, geographic distribution, molecular biology, biochemistry, genetics and molecular biotechnology. But despite the massive evidence from each of these disciplines, people still ask questions like how does evolution explain something as complex as the human eye? This is a worthwhile and challenging question. Could natural selection produce such a sophisticated organ? Yes it can. Read "In the Blink of an Eye," by Andrew Parker. The eye was one of the first organs to appear in nature beginning as simple light sensitive cells in the skin or covering of early animals. Then a depression formed under the light sensitive cells. Cover that over with a layer of transparent cells to focus the light. Slowly, over time we get a seeing organ attached to the brain. Parker traces the evolution of the eye through the major animal phyla in great detail. He also believes that the evolution of the eye is what triggered the famous Cambrian explosion. That is strictly a hypothesis and I don't know how much other biologists accept his link to the Cambrian fossils, but it is a fresh new outlook on why animal diversity expanded so suddenly in a 20-million year period in the Cambrian.

There are persistent myths about natural selection. Spencer's phrase "the survival of the fittest" is not entirely representative because of the ambiguity of the word fit. Some people equate the word fit as being the strongest, the toughest, and therefore having the greater brute force against any rival. That isn't necessarily true in evolution. A fit individual might well be a smaller less robust specimen who has some subtle advantage in life's struggle as opposed to more powerful individuals. Indeed, insect evolution has proceeded to smaller and smaller size. If you're small, you can find shade under a tiny leaf, drink a dewdrop to quench your thirst, hide from your enemies in a minute flower or find more food available to sustain your smaller nutrient requirement.

Natural selection does not gear toward advancement or necessarily a higher form. There is no goal in evolution. Nature picks for survival whatever works at the time. There is no mechanism to consider the future or where an adaptation might lead. Natural selection has no conscious control. Selection is operating all the time, but only in the present under the laws of chance. "Nice guys" don't always finish last as some people believe. There is a myth that evolution is an "improvement process." That depends entirely on how you define improvement. Is it an improvement If an organism finds it can survive better as a parasite than foraging with complete freedom? Most people would not think of that as an improvement or evolving to a higher form.

There are those who think animals evolve or adapt by "getting used" to something. There is a limit about how much we can handle adverse environmental factors, but evolution does not occur in this manner. Adaptations are inherited. You are born with them. If you weren't fortunate enough to get the right genes, you lose. We can burn our food faster and produce more heat in response to the cold, but it doesn't beat short stature, or a layer of insulating fat beneath the skin. You won't find very many tall skinny Eskimos. They are short, squat, and fat-faced for good reason. The tall skinny genes got eliminated by natural selection from the population ages ago.

There is much more to tell. This certainly isn't the whole story. I have not mentioned sexual selection, missing links, genetic drift, kin selection, the role of isolation, speciation, geographic barriers and a multitude of other related factors. I have attempted to do in three essays what Darwin did in a 500 page book. Hopefully these three essays will inspire further reading and remove some common misconceptions. Much has been learned since Darwin's time. The research in natural selection theory in the past 150 years is mind boggling. I hope you'll explore just a little of it.