

Not So Natural Selection

Nothing creates more misunderstanding of the results of scientific research than scientists' use of metaphors. It is not only the general public that they confuse, but their own understanding of nature that is led astray. The most famous and influential example is Darwin's invention of the term "natural selection," which, he wrote in *On the Origin of Species*,

is daily and hourly scrutinising, throughout the world, every variation, even the slightest; rejecting that which is bad, preserving and adding up all that is good....

Darwin, quite explicitly, derived this understanding of the motivating force underlying evolution from the actions of plant and animal breeders who consciously choose variant individuals with desirable properties to breed for future generations. "Natural" selection is human selection writ large. But of course, whatever "nature" may be, it is not a sentient creature with a will, and any attempt to understand the actual operation of evolutionary processes must be freed of its metaphorical baggage. Unfortunately, even modern evolutionary biologists, as well as theorists of human social and psychological phenomena who have used organic evolution as a model for general theories of their own subjects, are not always conscious of the dangers of the metaphor. Alfred Russel Wallace, the coinventor of our understanding of evolution, wrote to Darwin in July 1866 warning him that even "intelligent persons" were taking the metaphor literally.

The modern skeletal formulation of evolution by natural selection consists of three principles that provide a purely mechanical basis for evolutionary change, stripped of its metaphorical elements:

- (1) The principle of variation: among individuals in a population there is variation in form, physiology, and behavior.
- (2) The principle of heredity: offspring resemble their parents more than they resemble unrelated individuals.
- (3) The principle of differential reproduction: in a given environment, some forms are more likely to survive and produce more offspring than other forms.

Evolutionary change is then the mechanical consequence of variation in heritable differences between individuals whenever those differences are accompanied by differences in survival and reproduction. The evolution that can occur is limited by the available genetic variation, so in order to explain long-term continued evolution of quite new forms we must also add a fourth principle:

- (4) The principle of mutation: new heritable variation is constantly occurring.

The trouble with this outline is that it does not explain the actual forms of life that have evolved. There is an immense amount of biology that is missing. It says nothing about why organisms with the evolved characteristic were more likely to survive or reproduce than those with the original one. Why, when vertebrates evolved wings, did they have to give up their front legs to do it? After all, insects can have two pairs of wings and six legs, so there cannot be any deep general biological constraint on development. Why don't birds that live in trees make a living by eating the leaves as countless forms of insects do instead of spending so much of their energy looking for seeds or worms? Perhaps possessing characteristic A rather than B was just a secondary consequence of a different developmental or biochemical property that was variable and heritable. Or perhaps

characteristic A was the only available variation that differentiated the selected from the unselected organisms. It is these considerations that lie at the heart of Jerry Fodor and Massimo Piattelli-Palmarini's discussion of *What Darwin Got Wrong*.

Evolutionary biologists are of two sorts. A minority really do not care why one inherited characteristic confers a reproductive advantage to its possessors. They are content to show that such an advantage exists for a particular inherited difference, thus exemplifying natural selection. The dominant figure in experimental and observational evolutionary genetics in the middle of the last century, Theodosius Dobzhansky, spent most of his life showing convincingly from observations of both natural and experimental laboratory populations that natural selection was the cause of both the year-to-year stability and the repeatable seasonal changes in the proportions of certain variants in the chromosomes in natural populations of fruitflies.

Despite spending time every year on horseback, visiting localities in the Great Basin and California where he trapped fruitflies, Dobzhansky never, in fact, saw a fruitfly in its native condition. He collected living flies by putting out rotting banana traps, so the flies came to him, but from where he never knew. When flies were brought back to the laboratory and bred in large populations in which the proportions of the chromosome types were initially very different from the ones found in nature, those proportions changed in repeatable ways in a few generations. It was sufficient for him to be able to demonstrate that natural selection really worked.

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In contrast, most evolutionary biologists work on natural populations of plants or animals that they have chosen because they believe they can tell a natural historical story of how selection actually operates in a particular case. The most famous example is the increase in the black form of the wings in the peppered moth that has occurred in England since the mid-nineteenth century. The explanation offered and repeatedly appearing in textbooks (although since called into question because of faulty methodology) was that the moths rested on tree trunks where they were at risk of being eaten by birds. Before the spread of heavy industry the tree trunks were covered with lichens whose speckled appearance was matched closely by the "peppered" appearance of the moth's wings, so the camouflaged moths were only occasionally attacked. With the air pollution caused by heavy industry, the lichens were killed, so the moths were easily visible on the naked dark bark and were heavily preyed upon. A mutation to black wings appeared and was strongly favored by natural selection since the black-winged forms were now once again camouflaged.

There is little doubt that this example, widely taught in lectures and textbooks, had a powerful influence in convincing evolutionary biologists who came into the field from their prior interest in natural history that one could tell the causal story of natural selection. One unfortunate feature of this case is that the caterpillars of the dark-winged forms also have a slightly higher survival rate than those of the speckled-wing form, even though they are not black, so something more is going on, but this fact is not part of the curriculum.

The interest of modern evolutionary biologists in natural historical stories is partly a reflection of the origin of the science in the genteel nineteenth-century fascination with nature that characterized men of Darwin's social circumstances. The country curate who is an amateur collector of butterflies

is a cliché of Victorian life. The success of evolutionary biology as an explanatory scheme for its proper subject matter has led, in more recent times, to an attempt to transfer that scheme to a variety of other intellectual fields that cry out for systematic explanatory structure. As Hegel lamented in *The Philosophy of History*, “Instead of writing history, we are always beating our brains to discover how history ought to be written.”

One answer has been to transfer the formal elements of variation and natural selection to other aspects of human activity. It is by no means an anomaly that one of the authors of *What Darwin Got Wrong* comes to the subject from cognitive studies and linguistics. We have evolutionary schemes for history, psychology, culture, economics, political structures, and languages. The result has been that the telling of a plausible evolutionary story without any possibility of critical and empirical verification has become an accepted mode of intellectual work even in natural science.

The central claim of *What Darwin Got Wrong* is that “Darwin’s theory of selection is *empty*” (their italics). That is, to say that some trait was the object of natural selection and was established by the force of selection for that trait is to say nothing. If this seems a perverse claim, an example is helpful. There is a species of wild mouse that lives on both dark and light backgrounds. In the populations on light backgrounds the mice have what we think of as a “normal” mousy light brown color. The populations on dark backgrounds, however, are much darker colored. An evolutionary adaptationist argument that has been offered is that a mutation to a dark coat was favored by natural selection when it occurred in the population living on the dark surface because predators could not see the dark mice as well and so these mice survived better and eventually the gene for dark coats took over the population.

Fodor and Piattelli-Palmarini would argue that one cannot simply isolate coat color as the object of natural selection. They discuss the large body of evidence in many organisms of a number of complexities at the molecular, cellular, developmental, and physiological level that need to be taken into account as well.

First, the proteins that result from the processing of genetic information may enter into multiple metabolic and developmental pathways. From the earliest days of experimental genetics it was known that mutations that had been detected from a change in some obvious feature of an organism also affected other outcomes of the organism’s development and metabolism. For example, it is almost always the case that a mutation in fruitflies affecting any morphological character also reduces the rate of survival of the larvae, i.e., the worm-like early stages of development. So, any mutations that alter the normal dark red eye color of adult flies, making it bright red or orange or colorless, will also result in lower survival rates of larvae, even though they have no eyes.

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The causes of a reduction in survival in larvae that results from mutations with obvious visible effects in adults must be as varied as the morphological character in question, and it would require a detailed examination of the process of fruitfly development to elucidate. It is precisely this phenomenon that compromises the elegant natural historical story about the industrial dark color of the peppered moth or the story about predation in the dark-colored mice. Is it the dark coat and not some other metabolic product that is changed in dark-coated mice and that is responsible for their

greater success in reproduction? Perhaps the mice with dark coats are also more fertile or better able to digest their food.

It is, of course, not true that every process in a living organism interacts strongly with every other process. If interaction were both universal and effective, the organism would be so inflexible as to make life impossible and no evolutionary change could ever occur. The intensity of interaction between parts is also strongly dependent on the circumstances of life. Were I to lose the little finger of my left hand it would have little effect on my life, but if I were a cellist it would be a catastrophe. Thus it matters to the result of natural selection which of the possible multiple pathways of protein metabolism and interaction exist in each kind of organism.

Second, Fodor and Piattelli-Palmarini point out that there are molecular interdependencies that arise from the fact that genes are organized onto long thread-like chromosomes. The translation of a gene that is the first step in the process of producing a protein is sensitive to changes in DNA that is nearby on the chromosome strand, so that several genes of quite different specificity can be affected by the same change in the chromosome.

Third, the organization of genes onto the chromosomes in the cell means that when an offspring has inherited a particular form of one gene from a parent, it will also, with high probability, inherit the forms of a number of other genes that lie nearby on the same chromosome strand in that parent. It takes many generations for such historical linkages between genes on the same chromosome to be dissolved. Therefore selection on one function may result in inherited changes in other functions.

While Fodor and Piattelli-Palmarini put considerable weight on these actual functional interactions in organisms, the main issue for them has to do with how we describe the actual objects of selection. If we are to describe what is going on in nature as “natural selection,” then we must remember that it is not traits that are selected but organisms; the traits they possess as properties will determine what their contribution will be to the next generation. This is not an idle distinction because organisms will be “selected” as a consequence of their total biology. In our example we say that dark-colored mice are selected over light-colored mice. But not all dark-colored mice are candidates for natural selection because some of them might be sterile, or have a poor sense of smell, or any other of a vast list of properties that organisms may possess, and those properties may work against the survival of their offspring and thus their natural selection.

Moreover, an alternative way that selection might have acted is by selecting mice that were active only after dark when the predators could not see them, in which case color would be irrelevant. The fact that no such mice happened to exist at the time certainly does not rule out that they might have come into existence. Thus, to give a correct description of the objects of selection we would have to say that what was selected were mice that were dark-colored and not nocturnal. But suppose the mice could make a loud screaming noise that would frighten away predators. Then too, their color would be irrelevant so the correct statement is that what was selected were mice that were dark-colored and not nocturnal and made squeaky noises. We cannot stop there. According to Fodor and Piattelli-Palmarini our specification of what kind of mice were selected properly includes an infinite number of descriptors that take into account all the actual properties of our selected mice. This logic would then include that the mice are smaller than Manhattan.

The authors are driven to this by a logical necessity because we must, in fact, implicitly take into consideration why it was mice of a certain coat color and not, say, of a particular diurnal activity that were selected. If we are to understand the actual path of evolutionary change, the lack of variation in certain traits is of as much importance as the presence of variation in others. In fact, it often happens that artificial selection in the laboratory for a particular trait when replicated in different genetic strains results, in addition to the trait being directly selected, in different changes in other characteristics in the different lines. This is because in different strains genetic variation for different hitchhiking traits is present on the same chromosome as the genes influencing the directly selected trait.

One way to escape from the logical necessity of an impossibly complete specification of the actual living objects that are selected is to stop talking about “selection for” certain kinds of organisms and refer only to “selection of” the trait or traits that actually change as a result of the process of differential reproduction.

It is certainly true in artificial selection experiments that you don't always get what you asked for and there is no reason why the differential reproductive success in nature of different types that we call “natural selection” should not produce the same result. This alternative, however, will make most evolutionary biologists very uncomfortable, because they want to provide narratives of what is really happening to the different sorts of creatures in nature.

A major issue to which Fodor and Piattelli-Palmarini give insufficient attention is the concept of “adaptation.” They point out, correctly, that every living creature must be in some sort of adaptive correspondence to its conditions of life or else it would be dead, so the fact of apparent adaptation of living organisms to the world they inhabit is hardly a surprise. But the “adaptation of organisms to their environment” is a characterization of the relation between organism and environment that misses half the story. It is based on the metaphor of the “ecological niche,” a preexistent way of making a living into which organisms must fit or die. But there is an infinity of ways that organisms might make a living, an infinity of ways of putting together the bits and pieces of the external world. Which of these is an “ecological niche”? The only way to tell is if some organism makes a living in that way. Just as there is no organism without a niche, there is no niche without an organism. A famous example of how niches are defined by the organisms that inhabit them comes from the attempt to find life on Mars. How does one detect life on Mars? One suggestion was to send up a sort of microscope, collect some dust from the Martian surface, and see if anything wiggled. If it wiggles it is alive. This seemed too unsophisticated for the space scientists.

Instead they sent up a sort of vacuum cleaner filled with a nutrient solution containing a radioactively labeled simple sugar. If the dust sucked up from the surface contained living cells, they would start to grow and divide, metabolize the sugar, and release radioactive carbon dioxide, which would be detected by a counter. The Mars lander never detected any life activity although it was determined to be in perfect working order. But that does not mean that there is no life on Mars. It means that there is no life in Martian dust that grows on the sort of sugar provided. This device certainly would not have detected a science-fiction Martian. What the space scientists had done was to provide an ecological niche for a specific kind of life that they knew from earth, a niche that does not match a vast variety of earthly organisms. If you do not specify the kind of organism you are

looking for you cannot specify its ecological niche. Perhaps the space program should look again for wiggly things.

Fodor and Piattelli-Palmarini do not discuss the fact that every kind of organism, as a consequence of its life activities, reforms the world around itself and creates its own “ecological niche” that is in constant flux as the organism behaves and metabolizes. Organisms do not “fit into” niches, they construct them, and biologists’ realization of this fact has led to the creation of theories of “niche construction.”

It is not simply that birds and ants build nests or humans build houses. The metaphor of “construction” covers a number of activities of metabolizing creatures that create the world around themselves. Plants, putting down roots, change the physical structure of the soil in which they are growing and they extrude into the soil chemicals that encourage the growth of certain fungi. These molds, far from “infecting” the plants, form intimate connections with the roots that are a pathway for substances that promote plant growth.

In a great variety of organisms the chance of survival and the growth rate of individuals are not the highest at the lowest population density, but at intermediate numbers. Fruitflies, in their immature worm stage, for example, are farmers. They eat yeast that grows on the surface of the decaying fruit on which they live. The worms burrow into the fruit and the yeast grows on the linings of these tunnels. So, up to a point, the more worms, the more tunnels; and the more tunnels, the more food. Animals and plants create storehouses of energy on which they call in nonproductive times. Bees store honey and squirrels store acorns. Humans store grain and, in modern times, have a commodity futures market, so that affordable bread is available in the winter.

The most remarkable feature of terrestrial organisms is that each one of them manufactures the immediate atmosphere in which it lives. By use of a special kind of optical arrangement (Schlieren optics) on a motion picture camera it is possible to see that individual organisms are surrounded by a moving layer of warm moist air. Even trees are surrounded by such a layer. It is produced by the metabolism of the individual tree, creating heat and water, and this production is a feature of all living creatures. In humans the layer is constantly moving upward over the body and off the top of the head. Thus, organisms do not live directly in the general atmosphere but in a shell produced by their own life activity. It is, for example, the explanation of wind-chill factor. The wind is not colder than the still air, but it blows away the metabolically produced layer around our bodies, exposing us to the real world out there.

The appearance of Fodor and Piattelli-Palmarini’s book at this time and the rhetoric and structure of its argument are guaranteed to provoke as strong a negative reaction in the community of evolutionary biologists as they have among philosophers of biology. To a degree never before experienced by the current generation of students of evolution, evolutionary theory is under attack by powerful forces of religious fundamentalism using the ambiguity of the word “theory” to suggest that evolution as a natural process is “only a theory.” While *What Darwin Got Wrong* may have been designed *pour épater les bourgeois* and to forcibly get the attention of evolutionists, when two accomplished intellectuals make the statement “Darwin’s theory of selection is *empty*,” they generate an anger that makes it almost impossible for biologists to give serious consideration to their argument.

Conscious that Fodor and Piattelli-Palmarini may have overdone it, they have circulated an essay that assures evolutionary biologists that they are not challenging the basic mechanism of evolution as a natural process described by the four principles of variation, heredity, differential reproduction, and mutation. In particular, they reject any notion that natural selection is some sort of “force” with laws like gravitation. For them, natural selection is simply a name for the differential reproduction of different kinds in a population. Not to be misunderstood, perhaps biologists should stop referring to “natural selection,” and instead talk about differential rates of survival and reproduction.

The other source of anxiety and anger is that the argument made by Fodor and Piattelli-Palmarini strikes at the way in which evolutionary biologists provide adaptive natural historical explanations for a vast array of phenomena, as well as the use by a wider scholarly community of the metaphor of natural selection to provide theories of history, social structure, human psychological phenomena, and culture. If you make a living by inventing scenarios of how natural selection produced, say, xenophobia and racism or the love of music, you will not take kindly to the book.

Even biologists who have made fundamental contributions to our understanding of what the actual genetic changes are in the evolution of species cannot resist the temptation to defend evolution against its know-nothing enemies by appealing to the fact that biologists are always able to provide plausible scenarios for evolution by natural selection. But plausibility is not science. True and sufficient explanations of particular examples of evolution are extremely hard to arrive at because we do not have world enough and time. The cytogeneticist Jakov Krivshenko used to dismiss merely plausible explanations, in a strong Russian accent that lent it greater derisive force, as “idle speculations.”

Even at the expense of having to say “I don’t know how it evolved” most of the time, biologists should not engage in idle speculations.

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