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RESPONSE:

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ON EXPLANATION IN EVOLUTIONARY BIOLOGY

I appreciate Dr. Thorson's careful thought about biological function, and the new and interesting way in which Dr. Isaac has responded to those ideas. I hope to take this track a bit further, and talk mainly of two things: Kinds of explanation in biology (this has been raised in previous chapters but not yet described explicitly), and what is left when evolution

has had its way with teleology, or goal-directedness, in nature.

When explaining the traits of an organism, we can recognize multiple discrete levels of analysis or kinds of explanation. Respecting this point can avert countless futile arguments and misunderstandings. The evolutionary biologist Julian Huxley, in addressing the explanation of animal behavior in particular, saw three levels. I would say that they are equally relevant to all of biology, to any feature of any organism, not just behavior. The first is *physiology*, or mechanical causation, the actions of the vast array of bodily structures, including DNA, organelles, cytoskeleton, neurotransmitters, hormones, nerves, muscles, and so on. The second is *function*, or adaptation, the results of the action of natural selection on the traits of organisms across generations, due to the way environments influence organisms' likelihood of surviving and reproducing. The third is *phylogeny*, or evolutionary history, the patterns of traits that we see over evolutionary time within and between lineages. A fourth level was added by the Dutch ethologist Niklaus Tinbergen: *Ontogeny*, or development, the changes that an organism undergoes through its lifetime. Together these have been called the four questions or four pillars of ethology (the study of behavior), but today we should consider these more broadly as the ways in which biology can address the question of "why" for absolutely any trait, anything an organism does or is.

There is a nice symmetry among these kinds of explanation. Two are proximate, meaning that the relevant causes are within the same organism as their effects (physiology and ontogeny), and two are ultimate, the relevant causes being external to the organism and acting across generations (function and phylogeny). And, cutting across that distinction, two are mechanistic or process oriented (physiology and function), and two are temporal or pattern oriented (phylogeny and ontogeny). Not surprisingly, these four perspectives correspond to subfields within contemporary biology. My main point here is that the approaches are distinct but complementary. Each approach must be taken for a complete biological understanding of any trait. One cannot discover features at any one level by studying another. The same phenomena are being looked at, but with different glasses on, so to speak.

An example might help illustrate their complementarity. If we were to seek a biological explanation for why a particular man threw a rock, for instance, we would pursue one of four kinds of answers. From the perspective of physiology the answer has to do with, among other things, the brain sending messages over neurons to contract muscles, and so on. Functionally speaking, we might find that there was a hungry carnivorous animal running after him, and we might connect his behavior to adaptations that enable humans to recognize and instantly respond to immediate physical threats. Phylogenetically, we might start by noticing that throwing behavior is also present in our closest relative, the chimpanzee, and so we likely inherited that basic trait from a common ancestor at least six million years ago, if not far earlier; some squirrels can throw dirt at snakes, but they would have evolved that ability independently from our ancestors because many intervening organisms do not throw. And so that science would proceed. Lastly, a study of ontogeny would analyze how the ability and tendency to throw, including appropriateness and accuracy, develop throughout the early life of a human. Intensive and replicable methods are associated with each of these four kinds of biology. Here we have four complementary perspectives, all significantly explanatory, of a single trait, in this case a single event.

If we are to look at ourselves and our traits in an even broader context, leaving aside whether the perspective is scientific or not, I would add an additional explanatory level: *agency*. In the purely biological perspectives above, nobody bothered to ask the man why he threw the rock! This is because the levels were developed for the study of animal behavior, and we cannot ask the animals. But, regardless of where you stand on freedom of will, we can surely study behavior at the level of individual decisions for reasons and motivations, and the values that underlie them, and we can come up with conclusions that are just as distinctive and interesting as those at any other level. The study of agency may be informed by other perspectives but will never be reduced to them for the same reasons that none of the other four perspectives will never be reduced to each other: Because the agency approach is looking at something different; its methods and subject matter are complementary but distinctive to those of the other sorts of explanation. None of the other perspectives get into the

mind of an organism, as distinct from its brain, and study things according to the direct experience, the beliefs and desires, of an organism. The reason why biologists don't study agency directly is because we cannot do so, with our perspectives and tools. Psychologists can do it somewhat, by asking questions of their human subjects. Moral philosophers do it too, by trying to make sense of our beliefs and values. From this perspective we would answer the question of why a man threw the rock in terms of why he thinks he did it, why he wanted to do it, why he decided to do it.

Finally, many of us might want to step back as far back as we possibly can, to the most fundamental level of all, and approach human behavior through the lens of metaphysical or religious beliefs and values. Here we find another, complementary and yet distinct level at which we can approach traits and organisms—that of *ultimate purpose.* A major aspect of religion is the imbuing of, or a recognition of, a purpose and a destiny to creation, including humanity, the validity of which does not depend on any biological discoveries about our behavior, nor on our actual decisions and values. The Tao, for instance, is the Eastern idea of a Way that is the fabric of the universe, and of which we are a part regardless of whether we like or understand it. And from the Christian tradition, a line in the Westminster Catechism that I memorized as a child states that the "chief end of man" is "to glorify God and enjoy him forever." Any behavior or other trait could be analyzed in relation to that idea and the results would be distinct from analysis at any other level. Even if one disavows any religious belief or idea of a transcendent purpose to our lives, no one can deny that it is possible to analyze behavior from such a perspective. Surely this perspective is not scientific, although it shares some features with science such as the search for truth and the criterion of internal consistency. Nevertheless, theology, devotion, and meditation on metaphysical things constitute a longstanding and potentially internally coherent way to analyze human existence and behavior—in fact, a theological interpretation of human life has a more venerable history than any of the scientific levels of explanation. It is the level of explanation that addresses the deepest questions of existence.

I will assume that you in this crowd would like, or are at least are willing

to grant for the sake of argument, this sixfold list of complementary but distinct kinds of explanation in the study of life, four of which are germane to biological science (physiology, function, phylogeny, ontogeny), the fifth likewise arguably dealing with a product of evolution but only indirectly accessible to science (agency), and the sixth dealing with something that is not even a product of evolution and will never be accessible to science (ultimate purpose). The main reason I provided this outline is to highlight the mistake of pitting explanations of different kinds against each other as if they were alternatives, and to show how evolutionary explanation (both functional and historical) can always be appropriate, even though it can be inconclusive at any given time, and is certainly never exhaustive.

Given this framework, where is teleology, or goal-directedness? At first glance it seems to be in all of the levels of explanation in some way or other. The only two strong kinds are not at issue today: Agency is our own goal-directedness, and ultimate purpose, for those who accept it, is God's. We can set those aside. What remains, and what Dr. Thorson has emphasized is important for us to explore and understand, is the seeming goal-directedness that is accessible to science, in the first four levels of explanation, and especially in *function*. We must look at this more closely. What is responsible for function, or the organization towards function, in biological systems? The root answer, meaning the answer either directly or indirectly, in every known case so far, is natural selection.[25] There is no other mechanism known to science (and at this level we are restricting ourselves to science!) that can produce functional integration, to refine the parts of a system in such a way that they better accomplish something of benefit to that system. Natural selection is goal-directed only in a potentially misleading sense. It tends to produce a phenotype that is advantageous in an organism's environment, and over the long term seems exquisitely designed for it; but this is not because some natural process somehow anticipated that environment! Nor is it naturalistically inexplicable. It is because the environment, itself, skews the persistence of variants over the generations towards the relatively advantageous ones, through the inexorable competition among variable organisms in any given environment. This cyclical process, with mutation

as a generator of new variation, results in ever more precise functional fits of the traits of organisms to their environments. The goal-directedness in this amazing system is not inherent in the organisms themselves, or in the process of selection, so it does not merit the term "teleology". There is a sense in which organisms have teleology in a weak sense, but that is development or ontogeny, not function.[26] What we recognize in the organization of traits towards function is an even weaker sort of goal-directedness. The biologist Colin Pittendrigh introduced a term for it in 1958 called "teleonomy," and I think we ought to preserve that term.

A process is teleonomic when it proceeds in a biased or particular way, not because the process (or an entity undergoing it) has an inherent goal, but as a result of the regularities or laws that govern the operation of the system within which that process operates. So natural selection results in a change in the traits of a population of organisms in a specific way in a given environment, but that is because that environment filters the population every generation according to the relative functionality of the organisms' traits, and this process together with mutation causes the population to change in those specific ways. The environment that imposes selection and the variation within the population are acting in concert as a sort of conveyor belt, moving the average organism each generation in the direction of greater fitness. This cycle rigs the system to improve the fit of organisms to their environments, whatever they may be. This kind of process is teleonomy.

In this light I would say that our issues or troubles with organization towards function in natural systems are a result of two psychological tendencies that are very natural to humans, in fact probably ubiquitous. The first is the difficulty we have in internalizing and fully appreciating the novel discovery of evolution by natural selection—the astounding mechanism by which nature becomes a system rigged to generate organisms that work well, and ever better and better, in their accustomed surroundings. A hesitation to appreciate natural selection can arise simply from a vague disbelief that it could work or be truly as productive as it is. Second, the effects of natural selection are remarkably similar in a general way to the effects of our own design or agency; and this

similarity causes us inevitably to compare selection and agency, and sometimes even confuse them. But we must resist this temptation, now that we understand the biological mechanism, and we must respect the distinct roles of intentional and other teleological explanations as opposed to ones having to do with biological function.

I conclude with a couple of quality control points.

First, some concerns have been raised throughout these writings about the conclusion that mutations are random—concerns such as how we can know such a thing, what distributions and statistical tests would be required to demonstrate it, and so on. I believe that we can lay those concerns aside. They are an understandable result of the multiple ways in which the term "random" can be used. When evolutionary biologists say mutations are random, they still recognize that there are distinct causes of mutations, and identifiable patterns and biases in mutation. Many of these features are known, and in specific cases of mutation, causes no doubt will continue to be identified. All that is meant by random mutation is random *with respect to selection*: The likelihood of particular mutations is not affected at all by the functionality of the trait changes produced downstream from those mutations. The diverse causes of mutations do not include any feedback from whatever those mutations do to the traits that make them better or worse. If we ever do discover such feedback (and it certainly is theoretically possible, and some believe it exists), we will have to admit that mutations can be directed (by the environment), rather than being random with respect to it. So far we have not made any such discovery, and mutation remains random in this sense.

Second, I will take this opportunity to head off a strategy that certainly neither Dr. Thorson nor Dr. Isaac has used here, yet is common in some circles and often hovers around popular discussions of evolutionary explanation. This is the claim that evolution (and especially natural selection acting on genetic variation) cannot possibly explain some functional trait. This has never been, in my experience, a cogent argument. I do not mean that we have not discovered traits for which natural selection has not provided a direct explanation. We have. My point is rather that in every case where someone claims that a functional trait

cannot *possibly* have evolved by natural selection, this is never an empirical statement. There is no way to tell whether that statement is true; and in most specific cases where it has been used so far, it has already been shown to be false. Moreover, the impossibility assertion is never associated with a mechanistic alternative, but only the endorsement of an entirely different level of explanation, which is not to the point. Instead of a sober critique of evolutionary biology, I find such a claim to be an expression of (normal human) frustration at the limitation of our knowledge or imagination. In our science classes, we usually emphasize the *testing* part of the scientific process. This is certainly important, but the opposite end of the cycle of scientific praxis is hypothesis *generation*. This is a very difficult part of science, and one that becomes ever more difficult the more we know, because every plausible hypothesis has to explain all observations to date and be consistent with or supersede all current knowledge. I do not blame people, especially nonspecialists, for not being able to come up with hypotheses in any particular case, say, of a plausible evolutionary or selective history for a trait. But if we cannot come up with one, that constitutes an exciting opportunity—not to make negative pronouncements, but to continue to imagine, think, and explore. And we should remember the separateness of those levels of explanation. We gain nothing of deep moment, absolutely nothing, by failing to understand the function of a trait in biological terms.

THE WOODPECKER'S PURPOSE

A CRITIQUE OF INTELLIGENT DESIGN

WALTER R. THORSON

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Emily Ruppel, Editor

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