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DESIGNER THINKING

I WAS HOME FROM COLLEGE for the winter holidays. One evening I had settled into a comfortable recliner to read an old paperback on logic that I had discovered among my father's collection of books. It was cold outside and the house was noticeably still. I was alone, or so I thought. As with most books on logic, the topic of human rationality had to be broached, which this one did by noting that "we are all familiar with the definition of *man* as a rational being." At that moment, I heard a sound and looked up. I was staring into the barrels of two snub-nosed revolvers aimed directly at my head. The rational beings holding the guns were wearing ski masks. One of them ordered me to the ground, whereupon he bound my hands behind my back and placed my head face-down on a soft pillow. Any *comfort* that I may have felt was quickly dissipated when one of the gunmen suddenly turned up the volume of the television, releasing an explosion of sound that convinced me that I had but a few seconds left to live. Thankfully, my guests were thieves, not murderers. Nonetheless, at that moment I forever lost interest in what logicians have to say about human behavior.

Our commitment to the notion that humans are rational is as old as

philosophy itself, inextricably bound to an equally ancient need to associate ourselves with a higher being and distinguish ourselves from mere animals. Humans, according to this still-popular perspective, possess souls, which are the vessels that transport us from this life to the next. Deserving transport to salvation, however, requires all of us to choose correctly between good and evil, and this choice is made through the exercise of reason, a capacity that only we and God possess. Animals, on the other hand, are not members of this elite club, lacking souls and, therefore, the potential for an afterlife; without souls, it is argued, animals have no need for reason.

It has long been recognized, however, that animals cannot be so easily dismissed from the realm of rationality; indeed, they possess behavioral capacities that are reminiscent of the faculty of reason. How, then, many have wondered, can we account for these capacities without elevating animals to our level? The easy and comforting solution has long been to say that animals behave out of instinct.

Long before Darwin, philosophers, naturalists, and theologians noted and struggled to explain the complex behaviors of animals that, seemingly in the absence of learning, allow them to survive the challenges of the natural environment as if designed to do so. When Galen, the second-century Greek physician, extracted an infant goat from its mother's womb and placed before it several bowls containing such liquids as milk, wine, and water, he tells us that the kid chose the milk. Galen did not conclude that the kid was behaving rationally, but that it behaved as *if* it were rational. This form of rationality, however, was thought by Galen-and many others before and after him-to be the gift of a beneficent creator. For how else were such thinkers to explain the natural wisdom expressed by such lowly creatures?

The concept that we call *instinct* has had a long and convoluted history. Part of the difficulty in tracing the history of such a complicated idea is that language, culture, religion, philosophy, and science interact with such turbulence that one can rarely trace with confidence its trajectory

over time. Knowing the etymology of a word-for example, that *instinct* is derived from the Latin word *instinguo,* meaning "to excite or urge," and that it is related to the word *stimulus,* a contraction of *stig-mulus,* an "object that was used to prod mules"-provides some sense of place but, ultimately, does not satisfY. Etymology may inform us that the originators of the word *instinct* used it to denote the urge to act, but it cannot tell us whether that urge in fact originates in the mind of God or the mind of an animal. What we can say with some confidence, however, is that instinct has been repeatedly employed throughout history as a means of erecting an unbreachable wall between rational man and unthinking brute.

Reason and instinct. For many, these two terms are complete opposites, one denoting the freedom that empowers the human mind and the other the shackles that doom animals to a life of automatism. Despite their differences, however, reason and instinct reduce to a single concept that, when fully appreciated, provides a foundation for understanding many features of biological history across many dimensions of time and space. That concept is design. As we will see, designer thinking has permeated, and continues to permeate, topics as diverse as religion, evolution, mind, and human invention. Understanding the attractions and pitfalls of this form of thinking is essential if we are to understand the nature and origins of instincts.

The Argument from Design

A few years ago I attended a public lecture by a scientist who had written a book proclaiming that Darwin was wrong. The author of this book, Michael Behe, was promoting what many in the audience believed to be a new idea: that animals are the product of *intelligent* design and not, as Darwin argued, the product of *apparent* design. That Behe is a biochemist seemed to lend credence to his argument, as he shrewdly spoke over the heads of his non-scientific and predominantly religious-minded audience and wowed them with the complexities oflife in its most miniature forms. Consider the bacterium, he preached, with its flagellum

designed so magnificently for forward propulsion, like an outboard motor with all of its parts working interdependently to accomplish its function.
Such interdependency, he continued, could no more be the product of
gradual, blind evolution than a mousetrap. Each part of the mousetrap has a function only within the context of the complete device; remove the spring and the mousetrap is rendered completely-not only partlyuseless. Having deftly maneuvered his audience to this point, he was ready to complete the bait and switch: If an evolutionary explanation fails for a mousetrap, then how could it possibly not fail for a flagellum? To bring home his point, Behe projected onto the screen a mechanical drawing of the flagellum and its associated apparatus that looked like it had been removed from the desk of the mechanical engineer who had designed it. Nice show. The audience bought it.

And why wouldn't they. After all, this argument-the argument from design-has proven its rhetorical effectiveness for centuries. Although little more than an appeal to analogies between human and natural contrivances, the argument from design provided an important intellectual foundation for the religious faith of scientists and theologians alike, with Plato, Thomas Aquinas, and Isaac Newton among its many advocates. Three hundred years ago, Newton invoked the argument in his masterwork *Principia,* thus providing the imprimatur of the greatest scientist of his age. With such an ancient and esteemed pedigree, it is not surprising that it took an iconoclast like the English philosopher David Hume to write what many consider to be the definitive refutation of the argument from design, the *Dialogues Concerning Natural Religion.* Hume knew that he was addressing a touchy subject so, despite his iconoclasm, he arranged for his work to be published posthumously. As it turned out, Hume completed both the *Dialogues* and his life in the same year-1776.

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believer; and Philo, the skeptic (presumed by many to be the voice of

Hume himself). It is left to Cleanthes to enunciate the argument from design, which he does with great eloquence:

> Consider, anatomize the eye; survey its structure and contrivance, and tell me, from your own feeling, if the idea of a contriver does not immediately flow in upon you with a force like that of sensation. The most obvious conclusion, surely, is in favor of design; and it requires time, reflection, and study, to summon up those frivolous though abstruse objections which
> can support infidelity. Who can behold the male and female of
> each species, the correspondence of their parts and instincts, their passions and whole course oflife before and after generation, but must be sensible that the propagation of the species is intended by nature? Millions and millions of such instances
> present themselves through every part of the universe, and no language can convey a more intelligible, irresistible meaning than the curious adjustment of final causes. To what degree, therefore, of blind dogmatism must one have attained to reject such natural and such convincing arguments?

Cleanthes's choosing of the eye as definitive evidence for the creative hand of God was an obvious one. Indeed, explaining the origin of the eye's seemingly extreme perfection would prove to be a challenge to Darwin's theory of natural selection and, ultimately, one of that theory's greatest successes. As Darwin acknowledged in *The Origin of Species,* "To suppose that the eye with all its inimitable contrivances for adjusting the focus to different distances, for admitting different amounts of light, and for the correction of spherical and chromatic
aberration, could have been formed by natural selection, seems, I freely confess, absurd in the highest degree."

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process by which "numerous gradations from a simple and imperfect eye to one complex and perfect can be shown to exist, each grade being useful to its possessor, as is certainly the case." For example, we know of animals with mere patches of light-sensitive cells on the skin surface; animals with indentations on the skin surface that contain light-sensitive cells; animals in which these indentations are enlarged to form eye cups that direct light to the light-sensitive cells; animals in which the eye cup has closed to form a pinhole so that light can be focused; animals with eye cups containing a gelatinous substance that acts as a crude lens; animals, like us, with a more refined lens, as well as the ability to adjust the amount of light entering the eye. Thus, eyes did not evolve through the insertion oEready-made parts, but rather evolved such that even the most primitive eyes found throughout nature benefit the organisms that possess them. Better to see a little than not at all.

Although Darwin judges the human eye an organ of extreme perfection, we know that it is not. For example, what we call the blind spot can be reasonably described as the result of a design flaw, produced by a developmental wiring problem that any thoughtful designer, working from scratch, would have avoided. Hume may not have had such detailed biological evidence at his disposal, but he was acutely aware of the "inaccurate workmanship. . . of the great machine of nature," Taking this argument to its logical extreme, Philo ridicules the argument from design by noting the many imperfections to be found in the world. Thus, for all we know, our world "was only the first rude essay of some infant deity who afterwards abandoned it, ashamed of his lame performance." In time, this argument from imperfection would provide perhaps the most convincing evidence for evolution and against intelligent design. As the late evolutionary biologist Steven Jay Gould once noted, "Odd arrangements and funny solutions are the proof of evolution-paths that a sensible God would never tread but that a natural process, constrained by history, follows perforce."

Hume's *Dialogues* seriously wounded the argument from design by revealing its logical flaws. Then, also in 1776, the Scottish philosopher Adam Smith published *The Wealth of Nations* and dealt the argument a further blow. Smith's contribution was the notion that economic order can emerge when each individual is free to behave without constraint, as if an invisible hand (to use Smith's metaphor) were molding the order according to a grand design. Inspired in part by Smith's ideas, Darwin provided the knockout punch to the argument from design in *The Origin of Species* by providing a mechanism-natural selection-by which order can arise without thought, mentation, intelligence, or design.

Organic evolution plays out on a grand temporal scale-thousands and millions of years-and it was the cloak provided by the vastness of time that obscured the mechanisms of evolutionary change and enhanced the illusion of intelligent design by an unseen creator, that is, an invisible hand guided by an invisible mind. The direct link between God and mind was apparent to Hume who, in the words of Philo, asks, '~d if we are not contented with calling the first and supreme cause a GOD or DEITY, but desire to vary the expression, what can we call him but MIND or THOUGHT, to which he is justly supposed to bear a considerable resemblance?"

If the contrivances of nature, once imagined to be the product of a heavenly god, could be successfully moved to the realm of blind mechanism-of evolutionary trial and error playing out across the immensity of time-what about the contrivances of human beings, imagined to be the product of a creative, rational, purposeful, but more earthly mind? Is the man-made mousetrap evidence of the flagellum's intelligent design, or is a flagellum evidence of the evolution of the mousetrap? Before making the leap to humans, however, let's consider the role of trial and error in animal behavior.

Cat and Mouse

A rational mind lurking behind human contrivances is the foundation upon which the argument from design rests. It is a given. Two centuries

designed so magnificently for forward propulsion, like an outboard motor with all of its parts working interdependently to accomplish its function.

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ago, William Paley famously invoked the argument from design in his *Natural Theology, Or, Evidences of the Existence and Attributes of the Deity, Collected from the Appearances of Nature.* In that book, he contrasted the obvious simplicity *of* a stone with the equally obvious complexity *of* a watch to make the point that all complex objects must have a designer, whether it be a watchmaker or God.

Paley's error is simple yet profound. When we don't directly observe the developmental origins *of* any historical process, we naturally gravitate toward explanations that make the complex seem simple. Such explanations, however, are mere illusions. To avoid Paley's error, the first step is *to* ask: Where did *that* come from? The next step is to never stop asking that question.

As already mentioned, Darwin's theory *of* natural selection broke the spell *of* the argument from design by providing a natural path *to* the origins *of* organismal diversity on our planet. This radically new perspective *of* life and time removed thought and planning from a process that had been assumed *to* be the product *of* a divine mind. But does Darwin's perspective translate to other time scales? For example, what about animal behavior, which unfolds in seconds and minutes?

Toward the end *of* his career, Darwin eyed a successor, George Romanes, whom he hoped would apply the elder scientist's evolutionary ideas to animal behavior. The study *of* animal behavior was in its infancy at the end *of* the nineteenth century, relying *to* a large degree on the informal observations *of* amateur naturalists living and traveling throughout the world. Romanes collected and disseminated these often fanciful anecdotes as facts. For example, one anecdote recounted by Romanes gained credence by its being reported by several independent observers in Iceland. It was reported that mice work together *to* load provisions *of* food onto cow paddies, whereupon they launch the paddies, hop aboard, and navigate across the river using their tails as rudders. How could mice develop such extraordinary nautical skills? Perhaps, Romanes thought, the mice had observed humans loading

provisions onto boats and steering those boats with a rudder. All that was required from the mice, then, was the ability to imitate human behavior. *Of* course, mice have no such ability, and this fanciful story *of* marine-going murines has become a cautionary tale about the dangers *of* anecdotes; nonetheless, the story buttressed Romanes's conception *of* imitation as a primary source *of* novel behaviors.

Romanes's belief in the power *of* imitation is illustrated most famously in an anecdote concerning a cat that belonged to his coachman. Romanes had noticed the cat using its front paws to unlatch the lock on the gate at the front *of* the house. But how could a cat perform such a feat? Romanes arrived at a simple conclusion. He imagined that the cat reasoned, "If a hand can do it, why not a paw?"

While the anecdote *of* the Icelandic mice illustrates the unreliability *of* amateur observations, the ability *of* the coachman's cat *to* unlatch a gate has been observed countless times by countless cat owners.

Romanes's explanation *for* both anecdotes, however, is the same: imitation. Romanes was attracted to imitation because it seemed to him like a more simple and reasonable explanation than the two possible alternative explanations, namely, instinct and learning.

The reliance *of* Romanes on anecdote and unbounded conjecture fueled one young experimental psychologist, Edward Thorndike, *to* perform an experiment that simultaneously ridiculed Romanes and helped to found the scientific study *of* animal learning. For his experiments, published in 1899, Thorndike placed hungry cats inside small "puzzle boxes" *of* his own design, each version *of* the box requiring a unique set *of* actions that, when performed, opened the box and freed the cat to exit and receive food and water. Mter escaping, the cat was placed back in the box and tested again.

Thorndike made two important discoveries from this simple experi ment. First, he found that the time required to escape from the box decreased with each successive test, indicating that the cats were learning. But second, he found that cats learned to escape through a

process that had nothing to do with reflection and imitation. NaIve cats met confinement in the box with agitated and random behavior that occasionally, by happenstance, produced actions that opened the box. Over time, the cats' random agitation diminished and their behavior became increasingly directed toward the latch; eventually, the cats' behavior was so focused and efficient that, like Romanes's coachman's cat, the final form *of* the behavior *appeared* purposeful and human-like. Thorndike's point, *of* course, was that the purposefulness *of* a behavior can cloak the aimlessness *of* its origins.

The trial-and-error learning process introduced by Thorndike has been compared to natural selection. In trial-and-error learning, however, behavioral variability within an individual is reduced by weeding out the useless behaviors so that what remains, after many trials, is the elegant solution. In other words, the unfit behaviors are not reproduced in successive learning trials. And just as with natural selection, when we view the final product without having witnessed the process that led up to it, we are easily fooled into thinking that intelligent design is at work.

But does a trial-and-error explanation *of* some aspects *of* cat behavior provide any insight into the rational and purposeful behaviors *of* human beings? Do the behaviors *of* a trapped cat teach us anything about the invention *of* a mousetrap-about human creativity and ingenuity?

Failing to Succeed

Sitting in that audience a few years ago, listening to that modern purveyor *of* the argument from design, I was struck by Behe's confident assertion that human artifacts-clocks, computers, CD players-are created through a rational, thoughtful process. *Of* course this assertion is hardly new: recall William Paley's analogy between watchmaking and worldmaking. So, at the conclusion *of* his talk, I raised my hand and asked the speaker if he was aware *of* the possibility that even human artifacts evolve through a process *of* trial and error? The blank look on his face answered my question.

Henry Petroski is an engineer who has written extensively about the evolution *of* human artifacts. By examining in detail the history *of* such common, low-tech objects as pencils, paper clips, forks, and zippers, he provides a perspective that runs counter to the romantic image *of* the lonely inventor creating novel devices de novo using little more than reason and inspiration. On the contrary, according to Petroski, invention often is a trial-and-error process in which each successive development *of* an artifact is achieved through the removal *of* those features that don't work-those irritants that prevent an artifact from being as useful as it can be. Like evolution, design entails the removal *of* the unfit, producing in the end an artifact that appears to be the product *of* forethought, *of* intelligent design. As Thomas Edison famously expressed it, inventors fail their way to success. As Petroski expresses it, form follows failure.

Petroski demonstrates this evolutionary view *of* human invention through numerous examples. For instance, one may marvel at the beauty *of* the Brooklyn Bridge and see it as a stand-alone creation, but the reality is that, from the moment that the first man chopped down a tree and laid it across a creek, bridges have evolved through a trial-and-error process that has included numerous spectacular failures. Indeed, these failures are essential for future innovation. The same can be said for any *of* the great structural, architectural, or mechanical achievements, from the pyramids to the great medieval cathedrals to the space shuttle. One need not look to the great engineering achievements, however, to gain a sense *of* the evolutionary forces at play.

Consider a dining room table set for a formal function, replete with a variety *of* eating utensils: dinner forks, salad forks, dessert forks, carving knife, cheese knife, steak knives, fish knives, butter knives, dinner spoons, soup spoons, etc. For the most part, each utensil seems well-suited, perhaps even ideally suited, to the food for which it is intended. Upon observing such a fit between form and function, one might imagine that these utensils were designed for

their purpose by a small group of particularly insightful food fanciers. Not so, says Petroski.

The diversity of eating utensils can be traced to a co-evolutionary relationship between the knife and the fork (the spoon has a separate, but no less interesting, history). This history is convoluted, but it follows a logical progression and is shaped by a few fundamental needs. The first need is basic: getting food from the plate to the mouth without having to touch the food with one's fingers. Because many non-Western cultures consider it acceptable to use fingers when eating (to compensate, Mricans and Arabs have developed more rigorous cultural norms concerning hand-washing before and after meals), we are discussing here a tradition that arose primarily in Europe and was transported later to other parts of the world.

We begin with the knife, originally adapted from sharp pieces of flint. Over time, knife-making skills improved and, eventually, bronze and iron replaced stone. Knives were used for many things, including personal defense and, eventually among the more refined, eating. But how does one eat a piece of meat with nothing but a knife? Early on, bread was used to steady the meat for cutting, whereupon the meat was jabbed with the knife and conveyed to the mouth. But this was hardly an easy way to eat. So with the Middle Ages came the advent of the two-knife solution, one knife to steady the food and the other to cut, jab, and convey. Still, as a pointy utensil, a knife does not do a very good job of steadying food on its way to the mouth. For this job, at least two tines are necessary. The fork was born.

Initially, the two-tine fork was used primarily in the kitchen for carving and serving. These were large forks with widely separated tines, and they were useful in this role because the meat could be carved effectively and the fork could be easily removed from the meat. By the seventeenth century, forks began appearing at the dining table in England, but a new problem greeted this transition. Specifically, although a fork with two large, widely separated tines was effective for preventing rotation

when carving meat, such a design was not ideal for individual dining because the two large tines were not useful for spearing bite-sized portions of food and, moreover, the wide spacing of the tines was ineffective for scooping. These problems were addressed by the advent of the threetined fork, which continued to solve the rotation problem. In time, a four-tined fork evolved, followed by brief flirtations with five- and sixtined forks; these flirtations were brief because the width of the mouth sets an effective limit to the width of a fork. Ultimately, the four-tined fork won out, becoming the standard in England by the end of the 1800s.

The fork's impact on the design of the knife has not been trivial. First, the left-hand knife was replaced by the fork as a solution to the rotation problem. Then, the availability of a pointed fork diminished the necessity of a pointed knife. By the end of the seventeenth century, dinner knives were now blunted and, because two-tined forks were the norm at that time and were not ideal for scooping, knives were then given a broad surface to serve a scooping function. Thus has arisen the standard dinner fork and knife. The remaining standard utensils-and the many non-standard ones-have similar histories.

The evolution of eating utensils has shaped the cultural transmission of eating habits in surprising ways. For example, the European style of eating is derived from the history just reviewed, with the knife in the right hand cutting the food and pushing it onto the fork in the left hand for conveyance to the mouth. For some reason, forks were rare in colonial America but spoons were not. Thus, these colonists would use the knife in the European tradition but use the base of the spoon in their left hand to steady the food while cutting, after which the right (and typically more dexterous) hand would lay down the knife and pick up and flip over the spoon to scoop up the food for eating. This crisscross eating method became an ingrained American cultural tradition and therefore survived the introduction of the fork. These European and American behavioral traditions continue today despite the fact that forks, knives, and spoons are placed on the table in identical positions in

Europe and America; in other words, our history with eating utensils is a hidden force that continues to shape our culture and behavior.

Thus, human artifacts are no more the independent creations of any single individual than is the evolutionary invention of sonar in dolphins or echolocation in bats. In Petroski's words, artifacts

> do not spring fully formed from the mind of some maker but, rather, become shaped and reshaped through the (principally negative) experiences of their users within the social, cultural, and technological contexts in which they are embedded. . . . Imagining how the form of things as seemingly simple as eating utensils might have evolved demonstrates the inadequacy of a 'form follows function' argument to serve as a guiding principle for under
>
> standing how artifacts have come to look the way they do. . . . If not in tableware, does form follow function in the genesis and development of our more high-tech designs, or is the alliterative phrase just an alluring consonance that lulls the mind to sleep?

None of this is to downplay the significance of the individual's ability to identify and solve problems related to the design oflow- and high-tech devices. Petroski does, however, describe the process of invention in a way that is more satisfying than are facile appeals to human consciousness and other indefinable qualities. Humans are clever, ingenious, inventive, resourceful, and persistent. But we do not invent complex, or even simple, devices from a standing start through the mere application of our mind to a problem. We are not that smart.

The argument from design is more than a fallacious argument: it is a reflection of how the human mind works. When we are confronted with complexity and see no path to how that complexity originated, the appeal of the argument from design is immense:

What explains the ability of cats to open gates? *Design, through the action of imitation.*

What explains the ingenuity of human invention? *Design, through the action of reason.*

What explains the complexity of the human eye? *Design, through the action of divine creation.*

Of course, nothing is eXplained by these answers but, even worse, they numb the very impulse that might lead us to ask deeper and more profound questions. We are lulled to sleep.

Logic is one of the crowning achievements of the human mind, testimony to the promise of human reason. But logic does not guide human thought and action so much as it describes it. Yes, we can apply logic to a problem but, as we know, it takes training and practice to do so effectively. Moreover, we should be cautious about singing the praises of our logical and reasoning abilities when so many of our species' greatest thinkers have declared their allegiance to the argument from design even after its flaws were exposed.

Although my aim here is not to diminish the estimation of our capacity for complex thought, there is little doubt that our intellectual conceits have erected a wall between humans-guided by reason-and animals-guided by instinct. Darwinian thinking, however, does not abide such artificial and arbitrary barriers. So it is no surprise that from Darwin's time to the present day, many who wish to tear down this wall have sought to do so by demonstrating human *instincts* and animal *reason*. Whether one views such attempts as successful or not is related, in no small degree, to one's comfort with such terms as *reason* and *instinct* in the first place.

We have seen in this chapter the pervasiveness of designer thinking and, just as important, we have seen the many benefits to our understanding of the world around us by moving beyond the attractions of designer thinking and asking the next question about origins. When we ask questions about origins, we defeat designer thinking.

Of course, defeating designer thinking when the subject is silverware is one thing. Defeating the appeal to genes as the designers of

instinctive behaviors is quite another. And there can be no disputing the fact that-by and large-genes have become biological royalty, imbued with divine powers that are denied all other mere molecules. For those enraptured, the complexities *of* behavior cannot be comprehended without appealing to a genetic blueprint, a genetic controller, or a genetic program.

Sound familiar?

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SPOOKY

WITH GREAT FANFARE IN MID-FEBRUARY 2001, the preeminent scientific journals *Science* and *Nature* simultaneously published reports announcing the sequencing *of* the human genome. One report emerged *from* a private company, Celera Genomics, and the other *from* a publicly funded consortium headed by Francis Collins, director *of* the National Human Genome Research Institute. That the human genome was able to be sequenced at all had been doubted by many, but that the genome was sequenced so quickly amazed many more. Hailed as the greatest triumph *of* Big Science since the Manhattan Project, the Human Genome Project (HGP) was widely perceived as opening the door to a new universe *of* self-understanding.

Within only a few months *of* the *Science* and *Nature* reports, however, the grand pronouncements regarding the implications *of* the new findings were being replaced with more sober and forward-looking assessments *of* the next stage *of* research. Some were already beginning to stress the limited knowledge gained by the sequencing *of* the human genome. What was needed now, according to this view, was a comprehensive assessment *of* the actual proteins that the newly identified