

Why humans discover

David C. Lahti

Queens College, City
University of New York (USA)

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1. Introduction

We humans are a remarkably inquisitive and exploratory species, and very optimistic about discovery. We tend to assume that we live in a world that is orderly, intelligible, and accessible, such that we can reveal the reasons why things happen the way they do, that these reasons will make sense to us, and that explanations for natural phenomena must necessarily be the same for everyone everywhere. What rash confidence! What faith! Social theorists, philosophers, and others who encourage each other to divorce their thought from practicality can toy with abandoning this old-fashioned commitment, but even these people eventually power down their computers and walk around in the real world. There they, like the rest of us, implicitly expect things to operate by consistent rules that obtain in a physical universe that extends far beyond our individual or collective heads. Moreover, they, like all of us, benefit constantly in society from the way that this presumptuous “discovery attitude” has played out in the careers of thousands of scientists, engineers, and inventors.

To ask why are we like this seems trivial, an essay whose conclusion would be new to no one. We are intelligent, and intelligent creatures (in this sense) investigate things and want to understand and control their environments; and our unflinching confidence comes from the successes that we have had in such understanding and control. But a couple of provocative after-dinner questions will suffice to show that we hold diverse and contradictory opinions on these matters, and that an informed person can find two frequently argued and opposing views both very plausible.

First, *Are we naturally scientists, or was modern science made possible by a revolution in thought?* On the one hand, we can see today’s knowledge as continuous with early tool technologies and hunting practices, and then such developments as wheels, pyramids, calendars, and the discovery of the earth’s size and shape. In some sense, the growth of our understanding of the universe and its mechanisms has proceeded steadily, albeit exponentially in recent centuries, perhaps in proportion with human population growth. Our curiosity and abilities seem firmly rooted in human nature. Many who have been involved in major discoveries see themselves



as participating not necessarily in a rare pinnacle, but a basic root, of who we are. As U.S. astronaut Frank Borman said to a joint session of Congress, “*Exploration is really the essence of the human spirit.*”^[1] On the other hand, there is perhaps no ideological divide so decisive and obvious today than that between a commitment to scientific explanations of natural phenomena, and those who prefer other (one might say more primitive, although we must also include ‘postmodern’) explanations. As James Frazer said in *The Golden Bough*, human cultures seem to move generally from magic, through religion, to science, in explaining natural phenomena.^[2] Regardless of the precise truth of his progressive thesis, we are familiar with the distinction between these modes of inquiry, and few would quibble about the great practical explanatory success of science compared with the other two. Our understanding of how the world works has come not from birth dates or mysterious extractions of numbers from texts, but from the predictable and universal order of mathematics; and not from fervent pleas associated with holy sacrifices, but from repeated and tedious experimentation; and not from spells or miracles that violate the norm, but from predictable events that indicate generalities. From this perspective, modern science seems to be a radical departure from modes of thought that are more widespread and traditional for humans.

Second, *Does religion aid or hinder the growth of scientific knowledge?* Even those who are professionally devoted to this exciting—even inflammatory—question have arrived at two flatly contradictory answers, both of which are very plausible. On the heels of the previous question the “conflict thesis”^[3] would come to mind quickly: science is inherently different from other, non-naturalistic modes of inquiry, including religion, and so will inevitably be at war with them. From this perspective, we will not be surprised to read polls indicating that a majority of professional scientists are atheists.^[4] Even on topics where science and religion happen to agree, for example on the finitude of time or the harmfulness of incest, they agree for different reasons and thus seem to merely tolerate each other. But where they disagree, religion can be viewed as a hindrance to science, as science is to religion. For perhaps the best contemporary instance, many people a century and a half after the advent of modern biology still do not accept evolution, because of a religious commitment to an explanation they believe is contradictory. This case of religious hindrance to the public understanding of science is all too obvious, for example in debates over public school curricula.^[5] However, despite potent examples of conflict, many great scientists have not seen the relationship between religion and science to be inherently hostile. In notable cases this has gone far beyond mere fraternizing with the enemy, or lip-service to childhood influences. Many scientists, including Copernicus, Galileo, Newton, Boyle, Pascal, Faraday, and Einstein, have specifically attributed to their religions or other spiritual affinities a fruitful or even necessary contribution to their scientific practice and discoveries.^[6] Einstein wrote, “*The most beautiful experience we can have is the mysterious... the fundamental emotion which stands at the cradle of true art and true science.*”^[7] Even on a grander cultural scale, a claim almost as frequent in the history of science as the conflict thesis is that “Religion has undoubtedly played



its part historically in providing an intellectual climate in which modern science could flourish.”^[8] The mainstream of contemporary thought on this issue therefore encompasses both extremes: that religion is the antithesis and mortal enemy of science, and that religion prepared the ground for science and continues to nurture it.

In light of these peculiar controversies, the question of how the human attitude of discovery arose and developed into science becomes more interesting and challenging. Here I briefly sketch a hypothesis for such a history. This proposal accords with recent evolutionary thought as to the origins of human intelligence and sociality, and also aims to resolve the two controversies above. It is composed of two main parts, which correspond to two stages in the human story as well as to two different ways of understanding the notion of discovery or of being “scientific”. The first part looks at our deep history and addresses why humans are a discovering species. The second part looks at our more recent history and addresses how cultural features such as religion influence the discovery attitude. In this discussion (with the exception of the evolutionary prehistory of our discovery attitude because it is foundational), I will not rehash arguments for the two positions in each of the cases above, as I consider the literature to establish their plausibility already. Rather, in each case I will merely propose a link between the two contrary positions, a particular interaction that highlights how each side can be seen to have contributed effectively to the overall picture.

2. *De facto* science

No other species has exhibited behavior that goes so ridiculously far beyond what is required for survival and reproduction as we humans do. Admittedly, we have not explained in terms of reproductive value every widespread nonhuman animal behavior. However, the unexplained widespread behaviors of nonhuman animals are still of the sort that seem to be eminently explainable in terms of natural selection. The most outlandish apparent exceptions to this rule—such as elaborate traits, self-sacrifice, cooperation, and sufferance of manipulation—were largely explained by sexual selection, mutualism, and kin selection in the middle to late decades of the twentieth century.^[9] We are still working out the details of these theories and how and when they apply. Human behavior, on the other hand, including our curiosity and yen for understanding, is unprecedented, and some of it seems to fly in the face of predictions from natural selection. Few would doubt that there is reproductive value, and thus an evolutionary functional explanation, to a mind that can create better tools, understand the ways of animals and plants, or explore new areas. However, to suggest that we dig for Australopithecines, invent lasers, and characterize the space-time continuum because these discoveries lead to reproductive success seems to stretch evolutionary theory beyond its valid reach. This intuition has led some, perhaps most, to assume that much our ability to make phenomenal scientific discoveries is a functionless byproduct of a powerful mind that evolved for much more practical kinds of discoveries. If so, then the most we can



say about why we discover impractical and far-reaching things about our universe is that there are reasons why we *could* become this way, but no reasons why we *did*.

We should not rest easy with this explanation, for at least two reasons. The first is that other animals have not extrapolated their powers of understanding like we have, so our uniqueness in this respect begs an explanation. The second is a primary lesson we should learn from the operation of natural selection in nature: flamboyant excess is never neutral with respect to reproductive success; so, whether and how it could be neutral in the human case also begs an explanation. I suggest that the solution in both of these cases opens the door to an alternative to our typical non-explanation for the human radical quest for discovery.

The place to start is a brief review of why we are super-intelligent in the first place. Here evolutionary biology is coming to a consensus. I will use quotes from evolutionary social theorists to highlight the chain of reasoning. First, Richard Alexander explains how social competition has been the driver of our recent evolution:

"The hypothesis these various authors have developed gradually and collectively is that perhaps only humans themselves could provide the necessary challenge to explain their own evolution—that humans had in some unique fashion become so ecologically dominant that they in effect became their own principal hostile force of nature, explicitly in regard to evolutionary changes in the human psyche and social behavior. At some point in their evolution humans obviously began to cooperate to compete, specifically against like groups of conspecifics, this intergroup competition becoming increasingly elaborate, direct, and continuous until it achieved the ubiquity with which it has been exhibited in modern humans throughout recorded history across the entire face of the earth."^[10]

As humans became "ecologically dominant", we eventually became our own most "hostile force of nature". This means that in addition to adapting to predators, hunger, disease and climate, we came to evolve primarily in adaptation to ever-increasing competition with other humans. Intelligence, and in particular social intelligence of the kind that is necessary for effective competition in a highly social species, became the currency of survival and reproduction for humans.

Social competition in humans takes two forms: between-group and within-group. Success in between-group (group against group) competition requires a well-integrated and cohesive group, hence Alexander's statement above that our ancestors evolved to "cooperate to compete". However, we are of course not wholly cooperative within our groups. In fact, just as the most important influence on human group persistence is other human groups, the most important influence on individual survival and reproduction within a group is other humans in the group. Nicholas Humphrey describes the resulting situation:

"...in a society of the kind outlined, an animal's intellectual 'adversaries' are members of his own breeding community. If intellectual prowess is correlated with social success, and if social success means high biological fitness, then any heritable trait which increases the ability of an individual to outwit his fellows will soon spread through the gene pool. And in these circumstances there can be no going



back: an evolutionary 'ratchet' has been set up, acting like a self-winding watch to increase the general intellectual standing of the species."^[11]

The predominant modes by which social success is connected to biological (reproductive) success are in the pursuit of mates, other mutually beneficial relationships, and social status; as well as the interaction among these. These effects can be summed up as “social selection”—a subset of natural selection where traits germane to the social sphere influence individuals' survival, reproduction, and quality of parental care. Randy Nesse recently enumerated some of the traits social selection would foster in human society:

“What kinds of traits should we expect social selection to shape? It should shape traits that make an individual preferred as a social partner, including (a) high levels of resources (health, vigor, personal skills, powerful allies, status, territory, and other resources), (b) tendencies to share those resources reliably and selectively with relationship partners, (c) accurate intuitions about what others are seeking in a partner, and (d) strong motivations to please partners and other in-group members.”^[12]

Thus, a self-reinforcing process of selection would have driven humans to ever-increasing levels of skill, ingenuity, ambition, and other socially relevant traits. Some proportion of these would benefit an individual among one's own group members, and some proportion (overlapping with the first) would benefit one's own group among others. In general, and increasingly over time, early humans who were able to more efficiently exploit resources, to better understand relations of cause and effect, and to make useful contributions to society would have been more successful in this competitive scenario than those who were less adept at these endeavors. Such is the developing picture of human social evolution.

At this point we can integrate the attitude of discovery. In light of this story, the conventional opinion that our phenomenal discoveries are a neutral byproduct of our ability to solve practical problems seems too weak. We are not fervently curious simply because that trait has produced wheels, calendars, and projectile points that have benefitted the individuals who invented and knew how to use them. That answer might be effective for very early hominid intellectual evolution, but it becomes less and less effective as our ancestors became increasingly ecologically dominant, and increasingly each other's most hostile force of nature. If the social selection model is broadly correct, the radical intelligence and abilities we have today, including our attitude of discovery, cannot be explained without reference to our interactions with other humans. Functionally speaking, even our physical and ecological problems must be reinterpreted as primarily social problems. We did not need a wheel simply because it enabled us to move goods from A to B more easily. We needed a wheel because moving goods from A to B more easily helped us compete with other humans. Therefore we can take at least one step away from the conventional view: our phenomenal and often impractical scientific discoveries might be a neutral byproduct, not of useful engineering feats or inventions per se, but of the ability to outwit our fellows, for instance in the production of useful engineering feats or inventions.



One step is not far enough, however. It neglects our own exacerbation of this process, which eventually becomes the most powerful force behind it. Our intelligence did not evolve just because some individuals were cleverer than others and the cleverer ones survived and reproduced at the expense of those who were less clever. This is part of the story, but social selection is more than social competition. We did not wait around for competition to have its selective effect through evolutionary time. Rather, we focused and accelerated intellectual evolution by choosing mates and associates and (when possible) leaders that had valuable social qualities, as Nesse points out above. These choices then translated into better survival for the favored individuals, a better chance of reproduction, and a better chance that their children would survive to have children and care well for them. At the heart of the social selection model is the well-established idea that throughout our history, social acceptance has been the best guarantor of biological success, just as social rejection has tended to lead to biological failure. Thus, social selection has been as powerful an evolutionary tool in human hands as artificial selection has been. Through adaptive choice of mates and other relationships, we humans have essentially trained and bred each other for social intelligence and skills just as we have trained and bred animals and plants for work and food.

Thus I would hypothesize that our curiosity about the natural world and its mechanisms evolved in the context of social selection for that curiosity. Our tendency to investigate, to understand, and to achieve creative solutions was adaptive, not just through the immediate produce of those abilities, but through their social repercussions. The responses of critical observers, and the effects on our reputations in society at large, would have been the predominant route through which ingenuity would have been rewarded biologically. This is precisely the same feedback pattern that powers indirect reciprocity^[13]. Indirect reciprocity is the mechanism by which cooperative or beneficent behaviors are repaid by individuals throughout society, and even by society as a whole, such as through enhanced reputation. Indirect reciprocity explains the persistence of traits that temporarily incur an individual cost in service to others. This kind of social feedback works just as well for the constellation of traits that relates to practical innovations and discoveries. In fact, these discovery-related abilities are easier than morality to explain: they benefit the individual through both direct self-service and through group-service. Moreover, as in morality, we expect this social feedback to have become strong enough in human history that it has taken on a life of its own. Just as self-sacrifice or risk-taking in service to the group will tend through indirect reciprocity to lead to a reputation of heroism and high biological dividends regardless of the extent to which a particular instance of risk-taking benefits the group, likewise, extraordinary abilities in areas such as problem-solving, innovation, and creativity should lead to enhanced reputation even if a particular idea happens not to be very practical. The reason for this, again, is that the predominant source of selection maintaining such psychological traits at a latter phase of human evolution is not precisely the utility of a particular manifestation



of the trait, but the perceived utility of the trait in general. The implications of this point, if true, are far-reaching: our phenomenal discoveries, even if impractical, are not neutral byproducts at all, but function as indicators, as displays (whether consciously or not) of psychological traits that we have valued for millennia, and that we have selected in each other through choices in mating and other associations. Social selection, therefore, operates upon ingenuity and imagination and creativity—essentially, upon a discovery attitude—even if particular manifestations or effects of this attitude may not be practical. If we entertain this hypothesis, the fact that some scientific results may seem spectacular and impressive to us despite a lack of evident use or benefit, ceases to be so peculiar and inexplicable.

On this view, we are discoverers, one might say scientists in a sense, by nature. Through natural selection, especially social selection, we have evolved the kinds of minds that strive to figure things out and to produce interesting and effective ideas. But as our abilities have blossomed, the direct practical benefits to us of our ideas have come to contribute proportionally less to their selective benefit, as their indirect social benefits have come to contribute more. As long as creativity and curiosity tend to be advantageous, we will socially select individuals that exhibit these qualities, and we will not necessarily be concerned about the utility of their actual products at any given time (although some of us might be so concerned all the time, and all of us will be so concerned sometimes). This overall picture of the evolution of the discovery attitude is illustrated in Figure 1.

In this social selection scenario, it is not precisely the abilities of the individual that return the benefit, however, but the *perception* of the abilities of the individual by others. This can be a critical distinction, especially because of deception and power disparities. Given the pervasive role of competition in the evolution of human behavior, we can assume that differences in power among individuals have always influenced the process of discovery.

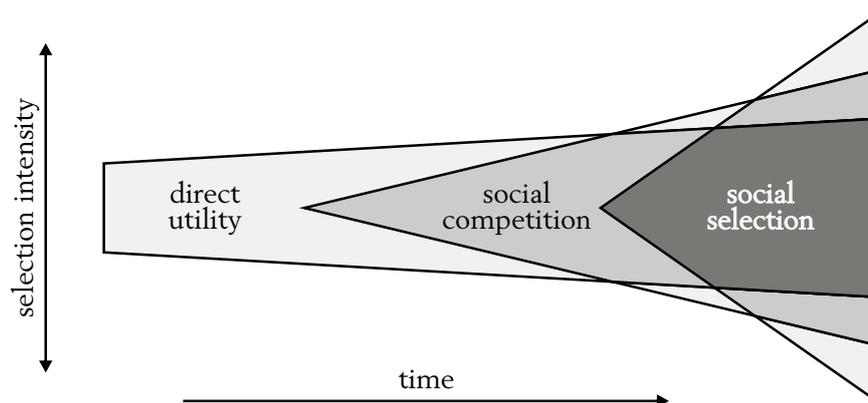


Figure 1. A schematic of the hypothesis presented here as to the predominant forms of selection on the discovery attitude in the ancestry of humans. At very early stages, starting with the very origins of cultural traits, our discoveries would have benefitted us only through their direct utility, and social learning spread these benefits quickly among group members. Eventually, however, ideas would become proprietary and a route through which social competition could act. Cleverer individuals could become more successful than less clever individuals as a result of their discoveries. At some point, perhaps as the benefits of being clever were approaching the practical usefulness of the discoveries themselves, social selection began to promote the unprecedented intellectual ratchet. Social affiliations, including mating and other relationships, would have favored clever people, people who are likely to make useful discoveries. In the latter stages of human cultural evolution, when reputation and cooperation became vital, social selection for a discovery attitude would have intensified far beyond the direct benefits of making particular discoveries.



Powerful individuals enjoy a disproportionate advantage in the production, perception, and benefits of new ideas. They can quash or commandeer the ideas of others. They can limit inquiries and competing claims. Owing to this influence, the ideas of powerful individuals might be lauded fearfully or sycophantically even if their methods are obscure and unreliable, and even if the resulting “discoveries” are not real. Not only is knowledge power, as Bacon noted^[14], but power is knowledge—to have power is to have influence over what people perceive as true. From this rather uncontroversial point, Marxists and other challengers of modernity have made a great deal of (more controversial) hay. The point here is that although social selection has fostered a yen for understanding and an ability to discover, it has also fostered the tendency to take advantage of others; these two traits interact, producing mixed results. These tensions leave continuing traces of ambivalence in the process of human discovery, as for instance when individual ambition thwarts intellectual integrity in science.

3. *De jure* science

Just as democratic governments and laws might “secure the blessings of liberty”, partly by limiting the influence of power disparities, we can likewise democratize the process of discovery in order to secure its advantages. This democratization, in particular an institutionalized transparency and reliability of method, is essentially the transformation of the ancient human discovery attitude into science. We are scientists in this official sense only if we participate in this cultural institution and adhere to its rules. Discoveries are scientific only if they proceed from the workings of this institution. Science as an institution is not codified in a written constitution or a set of laws, but is a sort of social contract, an implicit mutual agreement within a society. Many social institutions have been set up expressly to limit and channel social competition. Science is one of these. Most of us do not generally think of science this way, but the importance of this perspective is especially evident when one considers its primitive roots, as discussed in the last section. Three points are especially important in distinguishing science from its cruder and more freeform roots: (1) discovery is a public affair, (2) reliability of method is critical, and (3) cultural features can make or break science. I will go over these in a cursory manner, solely to the extent necessary in order to address finally our original questions about the revolutionary nature of science and the role of religion.

Any idea is formulated in the individual human brain, and so even if we knew nothing about intellectual competition and social selection for good ideas, we would be forced to admit that discoveries are made by individuals. However, the particular modes of discovery that we call science have an inherently social or shared aspect that ultimately derives from the group context within which our curiosity and inventiveness were originally manifested in our history. We have made this inherent social aspect a strict criterion for admission to the ranks of the scientific. Science is a public phenomenon, to the extent that no discovery is considered scientific unless its methods are repeatable and its conclusions testable by



other individuals. No intensely personal discoveries, those that cannot be generalized and independently assessed by others, are acceptable within science. Science admits of no arcane knowledge, no conclusions that depend inherently on the identity or nature of the individual making the observation or claim. This prohibition might exclude some real discoveries, but it certainly excludes a great many fake ones. It also rules out a notion of privileged individual access to truth that some would use to manipulate others. Science, in principle at least, and regularly in practice, undermines this sort of manipulation by requiring that methods be transparent and that anyone be able to make the same discovery by following the same procedures with similar data. Science is only concerned with what anyone could discover.

Despite its public aspect, science does not remove the importance of authority as the predominant means by which people know things or are acquainted with discoveries. No individual can possibly test even a significant fraction of what one accepts, and so each of us must take the word of others for most of what we know. The distinction of science with respect to authority is that it is adopted as a convenience, not as a replacement for testability. We might rely on a source in our decision to accept a hypothesis, but in these cases we are using the respectability of that source as an indication of how well the hypothesis was likely to have been tested. In cases important to us, for instance if a medical matter affects us or if we ourselves are scientists in the field, we can actually consult the published record of tests. Moreover, anyone who wishes, and has the abilities and resources, can test any particular scientific claim; and if adequately documented, the results would influence science itself, either by corroborating or challenging that claim.

Why accept conclusions we have not tested ourselves? The answer is the hallmark of science: reliability. There is no hallowed canon of scientific methods, despite the efforts of systematic philosophers of science to create them post hoc. All that is necessary in order for a method to be scientific is that it be public and reliable—that it be repeatable by others and produce the same results, and that alternative hypotheses for the results be excluded by the method. The first part of this is covered by the social aspect of science discussed above. The second part depends more on the experience, creativity, and imagination of individual scientists. The scientific method is usually described as a cycle, not only because of repeatability, but also because the exclusion of alternative hypotheses is contingent on our having imagined what alternative hypotheses are possible. Even when a particular explanation for a phenomenon has been so thoroughly tested that it seems beyond all doubt, a theoretical possibility remains, however small, that some new alternative hypothesis will be imagined that may force a new round of testing. Einstein's general theory of relativity, to cite the quintessential example, provides an alternative hypothesis to the absolute conception of space and time inherent in Newton's theory of universal gravitation and the three laws of motion. Einstein's theory happens to subsume and supersede that of Newton, agreeing with it on all points that had been supportive in 1687, but falsifying the earlier theory especially on certain points that



became testable only in the twentieth century. Of course, the greater the range of observable phenomena that are explained by a theory, the less likely an alternative explanation will ever arise. Eventually, retesting a broader theory becomes a routine and suspenseless process as scientists tend to concentrate on the details, even though every test of a detail is in a small way a test of the broader hypothesis. Thus, for instance, modern biology has explained so great a range of phenomena with evolutionary theory, that no alternative hypothesis has ever been proposed that can explain even a small fraction of these phenomena. Biologists therefore publish their findings no longer mainly as tests of the broader theory, but as tests of applications of evolution to particular circumstances and organisms. Still, results are theoretically possible that would call the general theory of evolution or the law of natural selection into question. As Darwin wrote, for instance, *“If it could be proved that any part of the structure of any one species had been formed for the exclusive good of another species, it would annihilate my theory, for such could not have been produced through natural selection.”*^[15] The incessantly self-critical and self-correcting aspects of science contribute to its reliability. Nevertheless, science is a human institution and is thus subject to human imperfection and corruption. The point here is not that science functions perfectly, but that it works on the whole—that it is humanity’s most reliable tool for discovery.

Moreover, in practice science can function at the level of the scientific community even when individual scientists fall short. Social competition is again the explanation: in general, the more a scientist or group of scientists parades a hypothesis after inadequate testing, the greater is the advantage to anyone who can topple it with more rigorous testing. Nearly every scientific discovery falsifies someone’s pet hypothesis, and any falsely touted explanation is an opportunity for another scientist’s victory.

Modern science has a similar function and requires essentially the same sort of capacities and the same discovery attitude that our ancestors valued in their social partners; modern science is just narrower, more efficient, and more reliable, despite—or rather, because of—its restrictions and limitations. We are all de facto scientists in that our nature is to be curious and inventive problem solvers. But some of us, particularly those who have received adequate science education, understand and endorse de jure science, the cultural institution devoted to curiosity, invention and problem solving. Today, when we ask or address questions about our world, we are employing both the older and newer faculties together. The modern discoverer is like a mariner looking at the stars with a well-honed feel for the old constellations, but formalizing this celestial navigation with sextant, chronometer, almanac, and charts.

By relating science here to discovery, I am not assuming that science is the only means of discovering something, although it is virtually by definition the only way in which discoveries can be made that are publically testable and are achieved through a transparent and reliable method. Still, many conclusions we make are not scientific, yet we would



consider them real discoveries. Everyone arrives at some conclusions by intuition, or a “felt” synthesis of available information. (Consider conclusions such as “This person loves me”, “I am ready to have a child”, or “This area seems dangerous, I am going to leave”.) In this paper I focus on science, which sets aside the fascinating question of the extent to which we can make discoveries by other means. The second half of the answer, then, to why we make so many discoveries, why we are scientific, in the more recent and restricted sense this time, has to do primarily with cultural and individual differences that interact with our shared evolutionary heritage. Culture has an overwhelming influence on the functioning of science. For certain people in certain social circumstances our essential, basic attitude of discovery has been quashed, whereas for others in other social circumstances it has been fostered and extrapolated and given greater structure and power. This cultural facilitation, led by a vanguard of notable thinkers and watershed discoveries, eventually led to modern science, the endless application of self-correcting methods of finding out about the universe, even to the point of addressing questions whose answers will not serve any pressing human need.

4. Predicting the effect of religion on science

Two implications from the roots of science as outlined above are that culture will facilitate exploration of the universe to the extent that it (1) creates a psychological and philosophical climate that favors discovery, and (2) protects the individual pursuit of excellence. The first point highlights that the positive role of culture in support of science is predominantly as a facilitator, a nurturer. Culture does not create scientists from scratch, if the evolutionary analysis described above is correct—our heritage as de facto scientists has prepared us for de jure science. All that modern science needs in order to flourish is a supportive cultural environment. The second point highlights that social selection and its driver competition were integral to the evolution of the discovery attitude in the first place, and are still crucial to the proper functioning of the institution of science. Science will only operate properly if people are permitted to compete on the basis of the quality of their ideas and testing. The spirit of both of these points is expressed by Caryl P. Haskins, once the President of the Carnegie Institution of Washington:

“A society committed to the search for truth must give protection to, and set a high value upon, the independent and original mind, however angular, however rasping, however socially unpleasant it may be; for it is upon such minds, in large measure, that the effective search for truth depends.”^[16]

These two implications or corollary hypotheses can also be applied to particular cultural institutions. Religion, for instance, has played a pervasive role in our conception of the nature of the universe and our place in it. The fundamental features of our discovery attitude, rooted in a basic curiosity and inventiveness shared with other primates, long predates religion in human history. Once religion arose, however, it must always have strongly influenced both our tendency to investigate nature and the interpretations we draw from our discoveries.



Among curious pre-scientific humans the evidence suggests that sources and kinds of knowledge were not clearly distinguished, such that explanations invoking what we would consider supernatural and natural causes coexisted more harmoniously than they do in scientific cultures today. The relationship between religion and science is more complicated after the rise of modern science, since the inherent formalization and restrictiveness of science necessitates the exclusion of supernatural explanations. To the extent that religion appeals to supernatural causes, the results are beyond the reach of science and are untestable; to the extent that religion appeals to natural causes, it is on science's turf and its conclusions can be tested—and either corroborated or refuted—by science.

Many scientists, historians, philosophers, and theologians have attempted to characterize the relationship between science and religion, each endorsing a model of conflict, independence, dialogue, integration, or some combination of these.^[17] These thinkers typically take an inductive approach, proposing generalities that explain historical and current events at the interface of the two disciplines. Following the line of reasoning above, however, we might deduce some aspects of this relationship, at least with respect to the impact of religion on science. Religion is not monolithic, so any hypotheses must be framed broadly and conditionally. In light of the history of the discovery attitude and its development into science, I propose three ways in which religion is likely to influence the tendency of humans to discover things about the world. I will present these optimistically as conditions of a facilitating or supportive influence on science, but I suggest that the inverse of each of these statements will also be true.

Religion facilitates or promotes the development of science in a culture insofar as:

1. The religion promotes consistency, universality, and contingency in our conception of nature
2. The religious morality fosters democratic ideals such as human equality and free inquiry
3. The religious worldview is holistic enough to permit or even inspire naturalistic explanations

The first stipulation relates to the philosophical and psychological climate that favors discovery. A world that is inconsistent, for instance subject to the whims of multiple independent deities or capricious forces, will yield no generalities, so it will not admit of human discovery. The expected human responses to such a world would range from worship and appeasement to helpless resignation. On the other hand, a religion that promotes an idea that the world operates consistently in time and space leaves open the possibility that humans can understand the underlying rules. Universality, the concept that these rules will be the same for everyone, is a precondition for discovery for the same reason; repeatability is only possible if we can expect results to depend on data and methods, not on the identity of the practitioner. Contingency is the concept that the world did not have to be, and did not have to be the way it is, as opposed to everything being necessary, or a foregone conclusion. A religion that portrays a contingent world is a spur to discovery, to *a posteriori* or empirical



investigation, observation and experiment. A religion that portrays a necessary world, on the other hand, encourages only *a priori* philosophizing as a way to find out about its principles and mechanisms. All three of these notions—consistency, universality, and contingency—are therefore crucial to us even bothering to understand the world. We know this now because science has shown that natural regularities do persist, that they are the same for everyone, and that we can indeed learn much more about the mechanisms of the world by observation and experiment than we can by “pure thought”.

The second stipulation, regarding democratic ideals, relates to the necessity of protecting the individual pursuit of excellence. An imposed hierarchy between those with privileged access to truth and those who are powerless and know little, is an impediment to the social aspect of science. As one evolutionary biologist writes,

“To the extent that any organized religion more stringently insists on unquestioning faith, acceptance of the divinity of leaders, and the absoluteness of the church’s dogma, it loses a part of the rationality of the original impartial-god-of-all-people. It loses the aspect that is most conducive to the growth of science.”^[18]

If, on the other hand, a religion fosters the view that any human has a native faculty of acquiring knowledge, such that all people have equal access to truth at least in principle if not in practice, people will have a reason and an opportunity to be scientific, to assess the methods and claims of others. In this ideal situation, our inherited creativity and curiosity will have a potentially productive outlet. Moreover, the more a religion encourages equality of knowledge-gathering opportunity, the more people with differing ideas (a diversity upon which science thrives for hypothesis generation) will be able to compete with each other on the basis of those ideas instead of being trumped by some other basis such as wealth, class, sex, or ethnicity.

The third stipulation hinges on whether religion endorses the reliability of method that is the hallmark of science. Religion deals, at least in part, with the nonempirical, the arcane, the unfalsifiable. Part of the mystery of religion is the absence of an objective method for assessing its claims and entities. This in itself puts religion apart from science. However, it does not necessitate a general antagonistic relationship between the two institutions. A religion can propose a theological or metaphysical explanation for something without challenging its naturalistic explanation, the explanation that is testable through the methods of science. This third condition is negative—science will not be hampered by religion when religion does not exclude it by fiat. If, *a fortiori*, religion actually encourages a holistic worldview with robust naturalistic explanations, then so much the better for its effect on science. Conflict between religion and science may not be inherent in the institutions, therefore, but contingent on how religion affects the culture with respect to science. Left aside here, but assumed, is that the religion-science interaction also depends on the continued intellectual integrity of science. For instance, individual proponents of science may have a variety of opinions including a



thorough rejection of religion, but we must remember that untestable pronouncements as to the usefulness or truth of religious attitudes or doctrines, whether positive or negative, lie outside of science.

5. Conclusions

The first controversy at the beginning of this paper was: *Are we naturally scientists, or was modern science made possible by a revolution in thought?* The second was: *Does religion aid or hinder the growth of scientific knowledge?* Both alternatives are plausible in both cases, for good reasons if the sketch above is true. The proposal here is as follows. We are naturally scientists; we have inherited a curiosity and inventiveness and yearning for discovery, which became especially prevalent in our ancestral context of social selection, and has led to technological developments, an avid investigation of our world, and a copious production of explanatory ideas. This is human behavior as *de facto* science. However, modern science was made possible by a revolution in thought, in its channeling and formalizing of our attitude of discovery into reliable methods and in the requirement that all results be repeatable and subject to independent assessment by others. This cultural phenomenon, in principle available to all but facilitated by particular social environments, is *de jure* science, science as we use the term today. Religion is a major determinant of the philosophical and psychological climate of a society, and can influence how and to what degree people attempt to explain their world. Despite the strong polarization in the public perception of certain areas of science such as evolutionary biology, the history of our discovery attitude does not suggest that religion is inherently opposed to science. I suggest here that religion can be expected to promote science insofar as it presents a universe that can be investigated and understood, protects the moral and intellectual freedom of individuals to conduct those investigations, and respects the resulting natural explanations for observed phenomena. Religion may hinder science when it fails to do these things.

These hypotheses regarding the prehistory of the discovery attitude and the contingent effect of religion on science have been discussed only in a summary fashion here, and need further development and testing. Regardless of whether they stand, a more general point remains. We may better understand why humans are so ambitiously curious and make so many and varied discoveries, by looking closely at how both our evolutionary history and our cultures have influenced the way we see the world.

Ignorance needs no explanation, no special mechanism—it is the default. It is where we were before we traveled an unprecedented evolutionary and cultural path. It is where we would still be today with respect to any of a million questions, if thousands of lifetimes had not been spent seeking and testing the answers. The etymology of “discover” seems to illustrate this perspective. It is almost a double negative: to discover, (from Latin *dis cum operire*), is



to move away from concealment, to *not* completely cover something. Without activity, all would remain hidden. We can appreciate an evolutionary and cultural contingency of our ability to discover anything at all. And whatever the means by which we came to be this way, regardless of any explanation or analysis, the endpoint will never lose its fascination: that a descendant of apes would eventually come to probe the origins, history, and mechanisms of the universe and its life.

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