EVOLUTIONARY BIOLOGY VERSUS INTELLIGENT DESIGN: RESOLVING THE ISSUE

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INTRODUCTION TO THE PROBLEM

In recent years, the public has witnessed a great deal of attention being given to the subject of teaching evolutionary biology in public school systems. Most notable has been the view that students should be presented not only with what is often termed 'the theory of evolution,' but that this theory should be considered alongside what has become known as 'intelligent design' (ID). Part of the basis for the reasoning behind this move has been the often-stated phrase, 'Evolution is just a theory, not a fact,' and ID can be treated in a scientific context just as readily as the theory of evolution. For instance, in his book, *Intelligent Design* (1999, pg. 13), W.A. Dembski states, 'Intelligent design is three things: a scientific research program that investigates the effects of intelligent cause; an intellectual movement that challenges Darwinism and its naturalistic legacy; and a way of understanding divine action.' As I will discuss in this article, the reason ID is seen as a viable scientific alternative can be traced largely to misunderstandings of the terms 'theory,' 'hypothesis,' and 'fact,' as well as the process of critically evaluating theories and hypotheses routinely applied in all fields of science. I address these misunderstandings for the purpose of providing the lay person with a better idea of what these terms mean and how they are used in science, as well as in everyday life. The goal is not to address the 'debate' often presented in the media under the guise of 'evolution versus ID,' as there is no actual *scientific* debate. Rather, I wish to show that the foundations for teaching science, as opposed to non-scientific approaches, requires accurate renderings of the principles that allow for the rational acquisition of understanding.

THEORIES, FACTS, AND SCIENCE: MYTHS AND MISCONCEPTIONS

In 2004, the school board for Dover, Pennsylvania, voted to have ninth-grade biology teachers read to students the following statement:

The Pennsylvania Academic Standards require students to learn about Darwin's Theory of Evolution and eventually to take a standardized test of which evolution is a part. Because Darwin's Theory is a theory, it continues to be tested as new evidence is discovered. The Theory is not a fact. Gaps in the Theory exist for which there is no evidence. A theory is defined as a well-tested explanation that unifies a broad range of observations. Intelligent Design is an explanation of the origin of life that differs from Darwin's view. The reference book, Of Pandas and People*, is available for students who might be interested in gaining an understanding of what Intelligent Design actually involves. With respect to any theory, students are encouraged to keep an open mind. The school leaves the discussion of the Origins of Life to individual students and their families.*

Notice that the Dover statement makes reference to a popular point of view, that 'evolution is a theory, not a fact.' This has the intended effect of implying that theories are less credible than facts, and since evolution is 'just a theory,' then it is reasonable to consider ID as a viable alternative. While much of the recent discussion surrounding the teaching of evolutionary biology in public schools has centered on views that '*Darwin's Theory is a theory*,' and, '*The Theory is not a fact*,' what these claims are intended to show is not correct. We need to understand what is meant when we use terms like fact, theory, and hypothesis in the context of science in order to engage in discussions regarding the utility of evolutionary biology relative to ID.

What are 'facts?'

Let's consider a simple example to illustrate what is meant when we use the term fact. Sitting in front of you on a table are the objects shown in Figure 1.

What you observe are *facts*. All objects and events you observe and experience, as well as those you do not, are *facts*. Facts are the objects and events that exist around us, and even within us.

Perceptions and hypotheses.

In looking at the objects in Figure 1, you might say that you 'see' some facts. But what does this mean? The first reaction you have to experiencing facts is that your brain produces a belief, which in this instance is the result of the rays of light hitting the retinas of your eyes, producing nerve impulses that travel to your brain, producing your mental reaction to the facts in front of you. There are relations between the facts and you, the perceiver, that causes you to believe something is the case. Namely, that 'there is a glass of ice water on the table.' In other words, you have developed *beliefs* about the *facts* in front of you.

Figure 1. The *facts*.

Two interrelated beliefs might be that (1) the object does indeed exist in front of you, as opposed to being a hallucination, and (2) what does exist in front of you is a glass of ice water. The process of reasoning from your senses to the belief that a glass of ice water is on the table is an attempt to explain the facts before you. In other words, you have developed a *hypothesis*. A hypothesis is an explanation of some set of facts, giving us at least initial understanding of what we perceive.

Having your belief, that what exists in front of you is a glass of ice water, you might then proclaim to others, 'Here is a glass of ice water.' You have communicated your hypothesis, perhaps for the purpose of giving others understanding of what they have observed of the same facts.

How did you arrive at *that* hypothesis?

What was the basis for reasoning that the *facts* before you, that you perceived via your senses, can be *hypothesized* to be a 'glass of ice water?' What allowed you to develop that particular hypothesis is that you applied a set of *theories* to what you perceived. At least two theories are easy to recognize in this instance: a theory of glass and a theory of water. A *theory* is an established or generally accepted explanatory concept, or set of concepts, that we apply to our sense perceptions to give us understanding of what we do or might perceive. Theories are usually stated as cause and effect relations. Thus, the relations between one's observations, as effects, and a theory would be to apply that theory to observations to develop a specific hypothesis of cause that accounts for the observed effects. Unlike hypotheses, which relate specific past causes to effects observed in the present, theories are time independent. They are applicable to the past, present, and future. For instance, we expect our theories of glass and water would be useful throughout the universe, but the hypothesis 'There is a glass of ice water on my table,' only applies to particular objects at a specific point in time. As we will see later, understanding this distinction is critical to the matter of evaluating evolutionary and ID theories.

It is when we apply some theory to our perceptions that we formulate beliefs and observation statements, i.e., hypotheses. For instance, we regard the theories of glass and water to be very well established given that we have had good success in the past in explaining a variety of observations referred to as glass and water, and we have been successful at making predictions based on those theories. Our understanding of the nature of glass and water are so well established that we do not hesitate to apply theories that represent that understanding. Thus, when we speak of our beliefs, observation statements, or hypotheses, these are all products of the interplay between facts and particular theories in the process of trying to understand our perceptions (Figure 2).

Hypotheses and theories are fallible.

We concluded earlier that what we see is a glass of ice water. But, there are never any guarantees that hypotheses, or the theories upon which they are based, are true. For instance, your friend might tell you that she thinks your hypothesis is not entirely correct, that the explanation of your senses is wrong, that at least some of the facts are not what you claim. In this case, what she would be suggesting is that you did not apply the relevant theory to your sense data. She might claim that, rather than being filled with ice water, the glass contains lucite plastic made to look like ice water. You might decide to then apply another theory (or theories) to your senses, say a theory about lucite, and as a result, you then consider a new hypothesis regarding the facts.

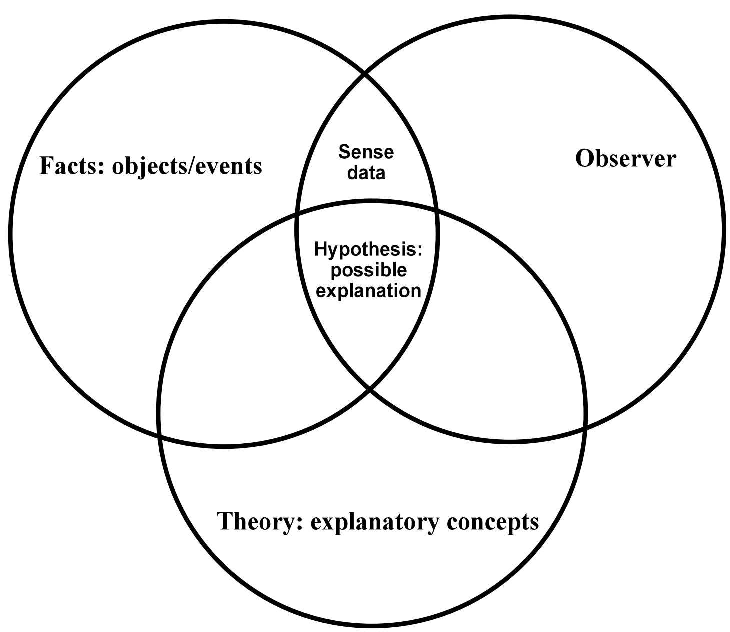

Figure 2. The interplay between *facts*, *observer*, and *theory* to produce a *hypothesis*.

Notice that we are talking about the fallibility of hypotheses, as well as theories. While a particular *hypothesis* or *theory* might be shown to be incorrect, the notions of truth and falsity do not apply to *facts*. Facts are what exist, regardless of who might be around to experience them, or not. It is you and I, as observers, who can be incorrect in our attempts to explain what we perceive.

Why be concerned with the nature of facts, hypotheses, and theories?

Humans want to acquire understanding of the world (and universe) around them. We have a remarkable capacity to perceive our surroundings, but that is a minor part of what we do. We want to understand what we perceive. All fields of science hold this desire for understanding as the ultimate goal. But, for this to be achieved, we must know what we mean when we use the words fact, hypothesis, and theory. The 'glass of ice water' example shows how we use *theories* and *hypotheses* to enable us to acquire understanding of the *facts* with which we come into contact (Fig. 2).

So, what is wrong with the Dover PA school board statement?

Remember that the statement included the sentences, '*Because Darwin's Theory is a theory, it continues to be tested as new evidence is discovered. The Theory is not a fact*.' This implies that theories are somehow less certain than facts, or that theories are to be given less credence simply because 'they are theories.' It is on this basis that evolutionary *theory* has been regarded by some as open to sufficient doubt as to make the inclusion of ID a viable *scientific* alterative to be considered in the classroom. But, as we have just seen, neither theories nor hypotheses can be equated with facts. Thus, to say 'this theory (or hypothesis) is just a theory, not a fact' is a misnomer, for the claim does not properly recognize the fundamental relations between facts, and hypotheses and theories.

Evolutionary biology has been profoundly successful for the very reason that it serves the goal of science – to provide avenues for the ever-increasing acquisition of understanding of facts. But, at any time we wish to critically assess the merits of any theory or hypothesis, we always need to be careful that we use our words correctly.

THEORIES, SCIENTIFIC AND OTHERWISE: HOW DOES ONE DECIDE?

In the landmark court decision in 2005 regarding the Dover PA school board requirement that ID be considered alongside evolutionary biology in science classrooms, US District Judge John E. Jones III noted that it is 'readily apparent to the Court that ID fails to meet the essential ground rules that limit science to testable, natural explanations.' While the court identified the seminal criterion for demarcating science from non-science as activities whose goals are the acquisition of understanding, we often witness a lack of clarity surrounding this separation. Indeed, this confusion exists not only in the lay community, but among some scientists as well. Part of the confusion lies in the fact that the term theory is often only thought to reside within the realm of science, such that evolution is claimed to be a *scientific* theory, whereas ID is not a theory at all. The problem with this reasoning is that it does not identify that there can be *non-scientific* theories, of which ID is one. Another part of the confusion is that the tenets of demarcation between science and non-science are often not presented by advocates of ID, or incorrectly presented, and science teachers apparently have not been particularly successful at stressing this demarcation.

We can readily identify the criterion that separates scientific from non-scientific theories and hypotheses, giving us the opportunity to understand what is meant when the terms theory and hypothesis are applied, and critically evaluated, in all fields of science, as opposed to fields such as metaphysics and religion, to which ID belongs.

Scientific and non-scientific theories - how are they different?

Recall that we earlier defined a theory as 'an established and accepted explanatory concept, or set of concepts, that we apply to observations to give us understanding.' Such a definition allows for theories to function in both scientific and non-scientific contexts, as has been the case throughout history that humans have applied a variety of theories to account for what they observe around them.

The criterion separating scientific and non-scientific theories and hypotheses is that of *testing*. The concept of testing traces back to the ancient Greeks, where one wishes to critically determine whether or not some explanatory paradigm successfully characterizes what occurs around us (or has occurred). If a theory or hypothesis is presented in a form that makes it immune to testing, then it can not be regarded as appropriate for consideration in any field of science, since there can be no evidence, potential or otherwise, that could be sought to refute it. The mechanics of testing hypotheses and theories will be outlined next using two simple examples. It is from these examples that we can identify ID as immune to testing, and as a result, lies outside the realm of science.

The mechanics of *hypothesis* testing.

Let's consider again our observation statement, 'Here is a glass of ice water' (Figure 1). Recall that the evidence from which we might infer that there is a glass and ice water on the table is that we applied to our sense perceptions at least two theories, glass and water. In other words, given our past experiences with use of these theories for understanding our surroundings, we believe those to be the best available for giving us understanding of this object on the table. Recall, however, no theory or hypothesis is guaranteed to be true. While we constantly attempt to explain, by the use of hypotheses and theories, what we perceive around us, no explanation is fail safe. The process of acquiring understanding is one of trial and error. We try out theories and hypotheses and judge to what extent they give us understanding. So how would one go about evaluating the ice water hypothesis?

If we assume the explanatory success of our theories about glass and water, and that our hypothesis is true, that there really is a glass of ice water before us, then there are specific predictions we can derive from our hypothesis. For instance, here are two predictions that follow from the theories and hypothesis: the glass should feel very cold and the ice and water should move freely in the glass. Notice that these conditions are expected consequences if we are dealing with ice water. We expect these consequences because of what we know of the theory of water that we have applied to our observation. In essence, we have stated two possible tests of our hypothesis, and we are now in a position to actually test it. You place your hand around the glass and immediately notice it is not cold. You move the glass and notice that the water and ice don't move. You even turn the glass upside down, and nothing pours out (Figure 3). Our predictions are not met, indicating the hypothesis to be false. The initial explanation of our observations in Figure 1 is incorrect.

So where does this leave us? Well, you continue to assume you are not hallucinating, and you do not think your theories are in need of revision – they have well tested in the past.

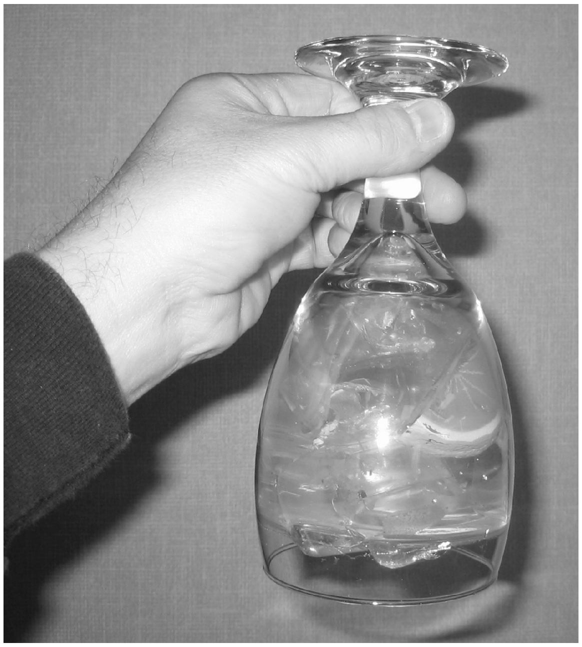

Figure 3. Our hypothesis, 'Here is a glass of ice water,' has failed the tests!

There is a glass on the table, but it is not filled with ice water. Since you have shown your hypothesis to be the wrong explanation, and you now have additional information regarding the substance in the glass (Fig. 3), you then entertain a new hypothesis: the glass is filled with lucite plastic made to look like ice water. In other words, at the point you decided your original hypothesis is no longer a worthy explanation, you applied *another* theory to your old and new observations, the theory of lucite, from which you produced a *new* hypothesis.

Here we have the fundamental process used in all fields of science to test hypotheses. If a hypothesis is not open to being tested, meaning that specific predictions cannot be formulated and subsequent observations made, even potentially, then there is no means to critically assess the utility of the hypothesis in our quest for understanding.

The mechanics of *theory* testing.

The basic principles outlined above for the testing of hypotheses also apply to the testing of theories in science. As a theory is a general statement regarding cause and effect relations, then the critical evaluation of a theory requires determining the accuracy of this claimed relationship. Just as predicted consequences serve as tests of hypotheses, such predictions are also the basis for testing theories. Let's consider a real example.

Albert Einstein's theory of general relativity, published in 1915-16, states that gravity is a manifestation of curved space and time. The theory ushered in a new revolution in physics and astronomy because it appeared to provide a broad explanatory framework, not only for what was already understood by way of Newtonian mechanics, but also accounted for phenomena previously regarded as anomalies in light of those mechanics.

To test Einstein's theory, that there is a causal relation between gravity and space-time, we would need to consider actual conditions where the actions of gravity could be observed. A fundamental prediction of general relativity is that rays of light, which are weightless, should be deflected at a specifiable angle in the presence of a gravitational field. An opportunity to witness just such an event took place in 1919, with the occurrence of a solar eclipse. At the point the moon completely blocks the sun, it would be possible to determine the positions of stars who's light passes close to the sun. Then, compare these positions with those when the sun is not in the field of view. If Einstein's theory correctly describes the affect of gravity on space-time, then the deflection of light rays from the stars should be the angle predicted by the theory, as illustrated in Figure 4. The resultant differences in eclipse and non-eclipse star positions was what was expected, thereby supporting the theory.

Theory and hypothesis testing: similar yet different.

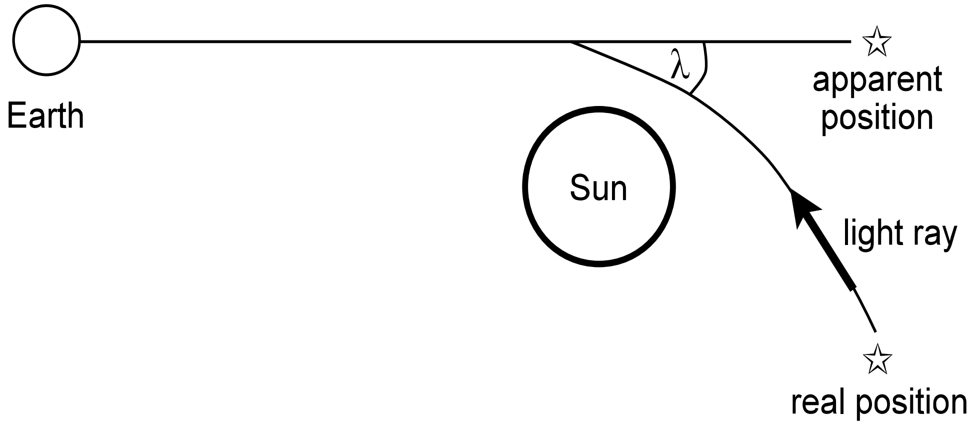

Figure 4. The deflection of starlight by the sun.

What you might notice from the general relativity example is that testing a theory is essentially the act of performing an experiment, whether occurring naturally, like the solar eclipse, or contrived by an individual in a laboratory. As theories state that under certain initial or causal conditions one should expect specific effects to follow if the theory is true, the way to test a theory is to witness the initial conditions and observe whether or not the resultant effects are as predicted. This is somewhat different from the testing of hypotheses, which make claims that specific causal events already occurred and what we hope to witness are predicted effects that support a hypothesis. While the testing of both theories and hypotheses rely on the predictions of consequences, the nature of those consequences do differ in content.

Recall from our hypothesis that there is a glass of ice water on the table (Fig. 1), we offered a causal account that explains one's sense data – that there is ice water in the glass. Since we were not present to witness the event of filling the glass, or examine the substance within it, we have no direct evidence of the link between cause and effect. So, to test this hypothesis we had to resort to predicting consequences related as specifically as possible to the suggested cause, but that are independent of the observed effect. The situation in the testing of theories differs in that we first observe, therefore know, the actual cause, and we then see what effect ensues, and determine whether or not that effect is what was predicted from the theory.

Consequences for Evolutionary Biology and ID

Now that we recognize the most fundamental mechanics for critically evaluating scientific theories and hypotheses, that of predicting crucial, observable (or at least potentially so) consequences, we have the most important benchmark that distinguishes evolutionary biology from ID theory. For any theory to be seriously entertained in the realm of science, one must at least be able to present the potential tests from which the necessary experimental and/or causal regimes might be formulated. Are such requirements possible for evolutionary biology? For ID?

One of the misconceptions regarding what is so often referred to as evolutionary 'theory' is that there is not one grand, all-encompassing statement that can characterize such a 'theory.' Rather, evolution is not a single theory, but a conglomeration of interconnected theories. This is readily recognized even in Charles Darwin's 1859 book, *On the Origin of Species*, where he showed the interdependence of four classes of events needed to explain differences between organisms over time: (i) organisms exhibit discernable variation; (ii) some of this variation is passed from parent(s) to offspring; (iii) more offspring are produced than can survive and reproduce; (iv) those organisms with traits that enhance their survival and reproduction will leave offspring with those traits, i.e., there is a process of *natural selection*. In the 20th century, with the development of fields such as genetics, population dynamics, and ecology, the fundamental principles comprising evolutionary biology (not theory) can be summarized as follows [adapted from D.J. Futuyma (2005), *Evolution*]: (1) genetic variation in the expressions of traits arises by random mutation and genetic recombination; (2) changes in the proportions of alleles (alternate forms of genes) and genotypes (genetic information) within a population may result in the presence of different genotypes between generations; (3) such changes in the proportions of genotypes may occur either by random fluctuations ('genetic drift') or by the nonrandom process of natural selection; and (4) due to the differential influences of genetic drift and natural selection, the traits of organisms in populations may diverge over time.

We readily see that we are not dealing with a single theory, but rather a set of theories, each of which plays a vital part when attempting to understand the vast past and present diversity of life. Especially throughout the 20th century, the principles of genetic variation, population dynamics, ecology, natural selection, etc., have been subjected to rigorous testing, and this process continues. To answer our question earlier in this section – are the requirements for testing possible for the various components of evolutionary biology – the answer is 'yes.' Whether laboratory experiments or field observations, the theories scientists apply under the heading of 'evolution' have been subjected to critical scrutiny. Such testing has been possible because science demands that observations be made of causes and checked against the evidence provided by effects, predicted or otherwise. Just as the correctness of any theory or hypothesis is never guaranteed, scientists continually seek evidence to judge their evolutionary concepts for acquiring understanding.

Can we speak so affirmatively of ID? Can a theory that suggests some purposive force or entity has driven, is driving, and will drive the diversity of life on Earth be tested? This question goes back to the basis for this article: can an ID theory be subjected to the same critical procedures of testing applied to all disciplines of evolutionary biology, much less all fields of science? As we saw earlier in speaking of the testing of theories, the nature of such tests have the character of experiments, where one must be in a position to witness both cause(s) and effects, such that the relations between the two can be judged as either supporting or refuting a theory. Is it possible to produce experimental conditions, much less natural conditions, that could potentially test any aspect of ID? Given the tenets of testing, it is clear that no area of biology could succeed at developing a valid test, much less produce test evidence that could support the theory as an alternative to evolution. For ID testing to be possible we would have to witness initial, causal conditions so as to be able to empirically identify the presence of the intelligent cause to which predicted effects could or could not be associated. Unfortunately, there are no conceivable test conditions under which such cause-effect relations can be discerned.[2] What

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[2] A more extensive discussion of the topic of testing a theory of intelligent design is provided in the companion article, *The Mechanics of Testing a Theory: Implications for Intelligent Design*, available at http://www.nhm.org/research/annelida/Mechanics_of_Testing.htm.

causal conditions one might witness would have to be based on scientifically acceptable standards, and the result would be that test consequences would inevitably be explained by natural, rather than supernatural phenomena. ID does not lend itself to the kind of scrutiny required of scientific theories. As such, the beauty of ID is that it allows one the luxury of explaining anything with impunity. But, as the goal of science is to acquire ever increasing understanding through critical evaluation, ID is at odds with that goal, which immediately precludes it from serious consideration in any realm of science.

CONCLUSIONS

What has been regarded as a debate over the teaching of ID as a viable scientific alternative to evolutionary biology in public school classrooms is really not a debate at all. The issue at hand is not that of teaching two competing *scientific* theories, but rather an attempt to interject a loosely formulated, *nonscientific* theory into the realm of scientific investigation. We have examined two of the common misconceptions that have been used to sustain this action: the distinction between fact and theory, and the requirement that hypotheses and theories be open to testing. If the most fundamental hallmark of all fields of science is that we want to continually subject our procedures for knowledge growth to the most critical evaluative processes, then ID falls so far from the mark as to not be worthy of serious consideration. This by no means is a criticism of one's desire to invoke ID. The criticism developed in this article is that the ongoing attempts to associate ID with science, and science education, are acts of misrepresenting the nature of scientific inquiry. The purpose of a science classroom curriculum is to teach the principles of doing science. The central issue in the discussion of evolution versus ID is not whether or not ID should be considered. The real issue is that all fields of science have established the criterion of testing as the hallmark that separates scientific from non-scientific approaches to acquiring knowledge. While ID is a theory in its own right, it is not a scientific theory, and thus cannot be considered in the science classroom.

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