Mutualism in the Darwinian Scenario

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An Unbalanced Dialogue

A significant factor in the secularization of Western society over the past 300 years has been the repeated attempts at demythologizing elements of Sacred Scripture by advances in science. By contrast, one hardly ever hears about criticism of science by theologians. I would suggest, however, that it is not healthy, either for religion or for science, that dialogue between them should remain a one-way street. Rather, as the late Pope John Paul II (Wojtyla 1988) succinctly put it: A more balanced conversation should consist not only of science purifying religion of error and superstition, but also of religion warning science against idolatry and false absolutes.

John Paul's concern prompts the question, "What does "a false absolute" in science, an endeavor that professes no absolutes, look like?" I do not have sufficient time to address the root assumptions of science here, but I would like to single out a few propositions used by some in science to challenge faith. There exists, for example, a widespread conviction on the part of secularists that the laws of physics are universal and never violated, and therefore they *determine* everything that we see. Thus, Nobel Laureates Murray Gell-Mann, Stephen Weinberg and David Gross proclaim that all causality points downward and that there is nothing "down there" but laws of physics (Kauffman 2008). In the same vein, the popular scientific figures Carl Sagan and Stephen Hawking (1988) wrote that there simply is "nothing left for a Creator to do". So prevalent is the belief in the absolute role of physical laws in nature that even a staunch theist like Philip Hefner (2000), a pioneer in the dialogue between science and religion, when asked if he believed in miracles, replied that "God just doesn't have enough 'wiggle room'."

I wish to suggest to you today that this widespread belief rests upon false absolutes. To be more precise, the attitude reflects an unwarranted minimalism on the part of physicists who should know better. To see why, I would like to examine the nature of universal laws, such as the four force laws of physics (gravity, electro-magnetic, and weak and strong nuclear forces). In order to remain universal (i.e. true at all times and under all conditions), such laws can be expressed only in terms of universal physical characteristics, such as mass or electrical charge. To measure these, it becomes necessary to ignore everything else about an object or a situation, except that which applies directly to the universal property under consideration (e.g., gravity or mass) (Bateson 1972). That is, the force laws of physics deal completely and only with these kinds of homogeneous properties (Elsasser 1981). Anything else that applies to the object or situation at hand is relegated to what is known as the accompanying "boundary statement".

Looking at the Fuller Picture

It is common knowledge in physics that a full statement of any problem requires two parts: The first part, and the one that commands the most attention, is the universal law or a set of laws that governs the behavior of a given system in a particular space and over a given time. The problem statement remains incomplete, however, until the investigator makes a second and accompanying statement about *relevant circumstances* that exist at the spatial boundary and/or at the start. This is called the boundary value problem. For example, one might wish to calculate the trajectory of a cannon ball. The appropriate law would be Newton's second law of motion in the presence of gravity. The specific trajectory and impact point cannot be calculated, however, until one stipulates the location of the cannon, the muzzle velocity and the angle of the cannon with respect to the earth.

The necessity of the "boundary statement" was made famous by Enlightenment believers called "Deists", who pointed out that, even in a wholly deterministic world, some "prime mover" had to pose the initial conditions. I would argue, even more broadly, that boundary contingencies in general must be absolutely arbitrary, because if one could identify conditions at the boundary to which the laws could not conform, then by definition the laws would not be universal. Given that circumstances at the boundaries must remain arbitrary, let us now examine the range of phenomena that qualify as "contingencies".

The reason why little attention is usually paid to the boundary statement is that boundary conditions have been implicitly assumed to be anything that an investigator *chooses* them to be. This attitude reflects tacit recognition that *intentionality* cannot be disqualified as a form of contingency. Usually, the chosen boundary conditions are of a regular and ordered nature; however, nothing prohibits boundary contingencies that can be characterized as "blind chance".

A Spectrum of Contingencies

History has shown the mathematical theories of probability and statistics to be quite successful in dealing with blind chance, by which is meant random events that are simple, directionless, indistinguishable and repeatable. But not all chance satisfies these criteria. For example, combined actions of multiple simple chance events can constitute a compound event. Such combinations need not be, and usually are not, directionless. Furthermore, physicist Walter Elsasser (1969) has shown that whenever more than about 75 *distinguishable* elements or chance events combine, the resulting amalgamation is referred to as physically unique, for it would take an interval more than a million times the age of the universe before that particular combination could be expected to occur again by chance. For example, if a photographer were to take a snapshot from the mezzanine of Grand Central Station that captures a crowd of some 80 travelers bustling below, there is simply no physically realistic chance that any photographer will capture exactly the same set of individuals at some later time. Moreover, at different times of day, it may be readily evident that different preferred directions are taken by a sample of travelers. Because they are not repeatable, unique events cannot be treated by common statistical techniques. I call such unique chance events “radical”, and such phenomena pervade the complex systems of ecology and the social sciences (Ulanowicz 2009a).

I now further contend that it is a false dichotomy (false absolute) to assume that a strict separation between chance and necessity is possible. In between blind chance and strict determinism lies a continuum of events characterized by the degree to which the arbitrary is constrained by the order with which it is fused. At one end of this spectrum blind, unconstrained chance occurs in a directionless environment. Once there are constraints of any sort, however, (like the imbalance of loaded dice) the resulting *conditional* probabilities will differ from those calculated for blind chance (Depew 2011). Going even further, Karl Popper (1990) pointed to conditional probabilities that grow progressively so constrained that certain outcomes dominate, although occasionally other “interferences” might still occur. For example, during the early 20th Century over nine out of ten young immigrants to America married someone from their own ethnic group, although a few would venture to take native-born spouses. Popper labeled such dominant outcomes (like the nine out of ten) “propensities”, and they were more general than laws, which he considered determinate only in a vacuum or under artificial conditions.

We thus recognize an entire spectrum of phenomena that legitimately can be called contingencies – starting with radical, novel chance, and running the gamut from blind chance to conditional chance to propensities and intentionality. It is a mistaken presumption to insist that blind chance and universal laws always act dichotomously in natural systems.

Order in the Face of Contingencies

By now some of you may be growing uncomfortable by my focus on the variety of arbitrary behaviors. If so many types of contingency are continuously at work everywhere, how is it, if not by determinate laws, that we observe so much order and regularity in nature? Of course, I acknowledge the necessity of laws in the creation of such regularities, but it doesn’t stop there. I also argue that laws explain less about what we observe than do configurations of phenomena known as *mutualisms*, or the even more numerous, indirect mutualisms.

Simple mutualistic behaviors were first treated in chemistry, where they were identified as *autocatalysis* (“auto” meaning “self” and “catalysis”, the act of quickening – a process that through its interactions with others tends to speed itself up). One may envision autocatalysis as a loop of processes, wherein each member accelerates its immediate downstream neighbor. In Figure 1 for example, if process A facilitates another process, B, and B catalyzes C, which in its turn augments A, then the activity of A indirectly promotes itself. The same goes, of course, for B and C. In general, A, B and C can be objects, processes or events, and the linkages can be deterministic (mechanical) or contingent.

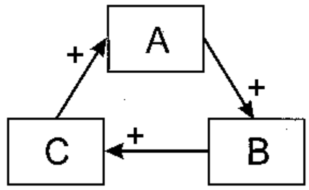
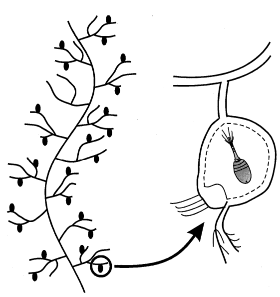


Figure 1: A three-component autocatalytic cycle.

My favorite ecological example of autocatalysis is the aquatic community that develops around a family of aquatic weeds known as Bladderworts. All Bladderworts are carnivorous plants, because scattered along the feather- like stems and leaves of these plants are small, visible bladders (Figure 2a). At the end of each bladder are a few hair-like triggers, which, when touched by any tiny suspended animals (such as 0.1mm water fleas), will open the end to suck in the animal, which then becomes food for the plant (Figure 2b). In nature the surface of Bladderworts always hosts the growth of an algal film. This surface growth serves in turn as ready food for a variety of microscopic animals. Thus, Bladderworts provide a surface upon which the algae can grow; the algae feed the micro animals, which close the cycle by becoming food for the Bladderwort (Figure 3).



(a) (b)

Figure 2: (a) Bladderwort stem with closeup (b) of bladder.

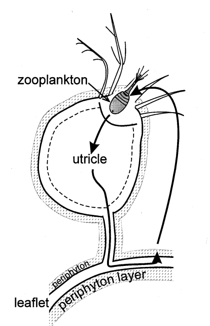


Figure 3: The cycle of mutuality in Bladderworts.

The autocatalysis associated with life processes, when it is impacted by random singular (chance) events, results in non-mechanical behaviors (Ulanowicz 2009a): For one, autocatalysis exerts selection pressure upon all its participating elements. If there happens to be some contingent change, for example, in the surface algae that either allows more algae to grow on the same surface of Bladderwort (e.g., by becoming more transparent) or makes the algae more digestible to the tiny floating animals, then the effect of the increased algal activity that contingency induces will be rewarded two steps later by more Bladderwort surface. The activity of all the members of the triad will be increased. Conversely, if the change either decreases the possible algal density or makes the algae less palatable to the micro animals, then the rates of all three processes will be attenuated. Simply put, contingencies that facilitate any component process will be rewarded, whereas those that interfere with facilitation anywhere will be minimalized.

One special feature of autocatalysis is essential to the life process: Thermodynamics requires that each step along the autocatalytic loop use energy and material to continue functioning. It follows from the argument used to explain selection that an increase of resource input to any component process will be rewarded. The result is that all the avenues of resources into the autocatalytic loop will be amplified – a phenomenon that I have called "centripetality" (Figure 4). Such centripetality, or pulling in, is evident, for example, in coral reef communities, which sequester major concentrations of nutrient resources well over and above those in the oceanic desert that surrounds them.

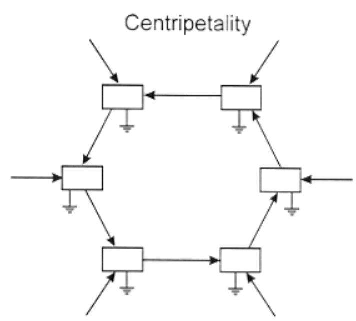


Figure 4: Centripetality resulting from autocatalysis. Arrows without origins are external inputs. "Ground" symbols are dissipations.

The ratcheting up of activity and its accompanying centripetality together constitutes what we commonly refer to as "growth". Growth, especially in the geometric proportions described by Thomas Malthus, played a major role in Darwin's narrative. Unfortunately, the growth side of evolution has been downplayed by the later disciples of Darwin to the point where it now appears as a given not warranting further attention. But Darwin's full dynamic is bilateral and might be paraphrased as "Growth proposes, natural selection disposes" (Stanley Salthe, personal comm.). Contemporary discussions of evolution overstate the eliminative role of nature, designated as "natural selection", but the enormous advantages imparted to some species via autocatalysis and accompanying centripetality remain virtually absent from the Modernist narrative.

A Foundation of Mutualities

Another imbalance in contemporary evolutionary theory is its inordinate focus upon competition. Competition with other organisms, in combination with elimination by adverse physical circumstances, is said to account for the bulk of natural selection. Like growth, the existence of competition is assumed as a given. But it is the existence of autocatalytic centripetality that allows us to explore the origins of competition. In particular, whenever multiple centripetalities arise within a limited pool of resources, *competition* among the associated configurations becomes the inevitable result. Viewed in this framework, competition becomes strictly derivative of centripetality, which in turn owes its existence to mutualities at the next level down. It is ironical that today one continually encounters conferences and papers devoted to resolving how observed mutualisms could possibly arise out of a natural world that is driven everywhere by competition. That problem, of course, is ill-posed, because it is mutuality that is fundamental and out of which competition ultimately derives.

Finally, the contemporary Darwinian scenario errs when it repeatedly and schizophrenically switches back and forth between random (chance) mutations of the DNA molecule and the (presumably lawful) behaviors of much larger organisms, such as feeding behaviors or camouflage (yet another example of the chance-necessity dichotomy). Excluded from this discussion is an entire spectrum of autocatalytic behaviors that are active at the biomolecular, cellular and organ levels. As I have argued, each such loop promotes the dominance of its participants and can change in response to impacts from radical chance events that occur *at each of the intervening level* (Ulanowicz 2005).

The Universal Conversation

In order to grasp the larger picture, I suggest that Darwin's full narrative resembles the ancient dialectic proposed by the early Greek philosopher, Heraclitus, who saw nature as the outcome of two opposing tendencies - one that builds up order and another that tears it down. Unfortunately, we have inherited from the followers of Darwin an obsession with only the latter half of that dynamic. A probable reason for such incomplete treatment has likely been a conscious effort to eliminate mention of anything that does not correspond strictly with the metaphysical picture of the universe as a clockwork, in which matter reacts solely at the behest of mechanical laws.

One does not even have to go as far as biology to realize just how one-sided the current view of our universe is. For example, the pre-eminent physicist John A. Wheeler (1980) was deeply troubled by simplistic thinking on the part of his colleagues who were studying the physics of elementary particles. His concern was constructivism[1] in physics that he thought was being mistaken for absolute reality, and he illustrated his misgivings via what might be called Wheeler's "parable of the parlor game".

According to Wheeler, the development of science is like a game played by a number of guests at a dinner party. Waiting for dinner to be served, the guests elect to play the game "20 Questions" the object of which is to guess a word. In Wheeler's version, one individual is sent out of the room, while those who remain are to decide upon a particular word. It is explained to the delegated person that upon returning, he/she will question each of the group in turn and the responses must take the form of a simple, unadorned "yes" or "no" until the questioner guesses the word. After the designated player leaves the room, one of the guests suggests that the group *not* choose a word.

[1] Wheeler apparently was attributing a dual sense to the word, "constructivist". He worried that the body of scientific theory was being "constructed" in the philosophical sense of the word, *and* as well that some of the particles being discovered were being physically constructed by the experimental apparatus and procedure.

Rather, when the subject returns and poses the first question, the initial respondent is completely free to answer “yes” or “no” on unfettered whimsy. Similarly, the second person is at liberty to make either reply. The only condition upon the second person is that his/her response may not contradict the first reply. The restriction upon the third respondent is that that individual’s reply must not be dissonant with either of the first two answers, and so forth. The game ends when the subject asks, “Is the word XXXXX?” and the only response coherent with all previous replies is “Yes”.

Contingencies That Stipulate Order

What usually strikes people first about Wheeler’s parable is the indeterminate nature of the outcome. The parallels with evolution, however, are richer still. Of especial interest are the rules of the game, which are meant to correspond to the laws of nature. One sees immediately that the rules do not determine the endpoint. They guide and constrain activity (presuming that the participants abide strictly by them), but they cannot of themselves specify the outcome (Ulanowicz 2012, Longo et al. 2011). This accords with our foregoing discussion about the role of physical laws in evolution. Those laws are not violated, but universal laws cast in terms of simplistic generalities are insufficient to deal with a hyper-astronomical number of possibilities and to designate a single outcome from among the enormous number that satisfy all of the laws equally and exactly.

In Wheeler’s game the specific outcome is the result of a dialogue between two parties. On one hand, the questioner is seeking to narrow progressively the field of possibilities, while the intent of the rest of the players is to maintain that field as wide as possible for as long as feasible. In nature the role of the questioner is played by natural selection, not only in its traditional eliminative sense, but also as part of the autocatalytic action that promotes the growth of its members while drawing resources away from non-participating elements Both actions, eliminative and autocatalytic, serve to narrow the number of persisting elements. In the same way that successive respondents in the game choose answers that will keep options open, selection in nature is opposed by all the arbitrary, redundant, inefficient and noisy events that constantly degrade existing constraints within the system, while at the same time creating a broader manifold of new possibilities.

Of course, all metaphors are imperfect, and Wheeler’s parable is no exception. It culminates in short order at a fixed endpoint, whereas natural evolution continues to act over deep time. Furthermore, the natural “dialectic” between selection and disordering is not simply one of direct opposition. As philosopher Georg Hegel pointed out, many dialectics are carried out at more than one level. While in the short run the two tendencies are antagonistic, over the longer term they can grow mutually interdependent: In order for autocatalysis to perform selection, it must have access to a continual renewal of contingencies. Conversely, the more rigidly streamlined a system operation becomes, the more resources it captures and dissipates. The two exist in tension with one another; neither trend can totally eliminate the other. Systems without structure and efficiency cannot compete; those without flexibility cannot adapt. One-sided maxims, such as unbounded efficiency, have no viable place in a realistic evolutionary theory (Ulanowicz 2009b).

Such disparities notwithstanding, Wheeler's parable suggests an astounding conclusion: It is not universal laws that create the many enduring forms that comprise the world. Rather, it is a transaction between opposing *contingencies* that actually results in the history that we inherit. Laws necessarily mediate the ongoing exchange; but they do not *drive* it.

The Drama beyond Physics

This new and wider perspective on evolution has manifold implications for science, for society and for theology. We recognize now that we do not inhabit a clockwork universe – one in which everything is determined in rigid mechanical fashion by the laws of physics. Rather, as John Haught (2012) has suggested, a more appropriate metaphor for an evolutionary world is the drama, wherein the theatrical elements of unexpectedness, continuity and time correspond in nature to contingency, self reference and history, respectively. The popular material/mechanical depiction of the brain as a determinate machine must yield to one of a human psyche that exists at several interdependent levels and exhibits sufficient flexibility to act in an autonomous, intentional manner (Juarrero 1999). In the wider evolutionary scenario, "free will" isn't just a possibility, it is central to the notion of humanity.

An expanded evolutionary narrative presents theologians with manifold opportunities and challenges. That universal laws do not determine this complex world reveals an abundance of heretofore unrecognized "wiggle room" at all levels of the universe. The Deist notion that God could have acted only at the beginning of the universe was far too narrow. The larger view finds the Creator with ample opportunities to remain in continuing dialog with creation. In particular, divine intervention no longer appears as an absurdity, nor is intercessory prayer necessarily ineffectual.

Perhaps the greatest challenge to faith for the largest number of people is the existence of suffering and evil (theodicy). A more complete description of evolution does not entirely resolve this enigma, but it does provide a new angle on the problem (Ulanowicz 2011, Domning and Wimmer 2008). Without contingencies there can be neither evolution nor progress. As in the parable of the weeds and the wheat, eliminating all evils would impair opportunities for doing good and going forward. Thus, there are solid rational reasons to avoid Puritanism. Rational accommodation, however, does not extinguish the existential pain in the wake of catastrophic natural calamities or massive social evils. Such anguish can be dealt with only through the light of faith.

Theological Concerns

Doubtless, some Christian theologians will object to the process-based view of evolution outlined here, because it seemingly contradicts the Neo-Platonist foundations of both medieval theology and Enlightenment science. Plato taught that pure, unchanging essences exist in relation to which all real entities bear incomplete correspondence. By contrast, process theology and evolution would suggest that God would actually change. Here a popular notion from ecology might point the way to a reconciliation of sorts. Ecosystems are regarded by most ecologists as existing across a succession of levels, each characterized by a particular range of space and time (Allen & Starr 1982). Such levels couple only loosely with one another and connections between any two domains decrease with increasing distance between them (Salthe 1985). Phenomena at the largest scales appear constant relative to those at lower levels, just as the stars appeared fixed to ancient astronomers. Now, it would be unnecessarily restrictive to confine a Supreme Being to only the highest levels; God is present and active at *all* levels. Insofar as God exists at the highest realm, the Godhead remains unchanging. Inasmuch as God may be active at lower levels, however, and in particular at human scales, God is free to react and change in response to the continuing dialog – as has been portrayed in scripture and Church history.

What theists are most likely to object to in this expanded notion of evolution is the dominant role played by contingency. To some the preponderance of contingency seems to play into the hands of those evolutionists who contend that everything visible is the consequence of blind, directionless chance. As I have argued, however, contingency covers far more than blind chance. It even extends to intentionality (which, because it is contingent, is a manifestation of free will). Although the genesis of some phenomena might be traceable to a particular class of contingency, the origins of many others will remain perforce ambiguous (Ulanowicz 1999): Was that particular job opportunity a matter of random luck, or was the hand of some higher agency at work? Was that tsunami due to an Act of God, or was it blind chance? The answers to such questions lay shrouded behind an "epistemological veil" (i.e., remain unknowable), and it falls to the particular faith of each observer to choose one way or the other (Ulanowicz 2009a).

Even having accepted such necessary ambiguity, some believers may remain unwilling to admit contingencies as the origin of all distinguishable phenomena. The idea of tracing all histories to seemingly arbitrary events seems to contradict all semblance of a planned creation. This objection, however, rests on our habit of seeing all events as being "pushed" into existence out of the past. It would be unnecessarily restrictive to confine the action of God to our own limited horizons. Rather, scripture (Genesis 1:3) and theologians (e.g., Teilhard 2004, Haught 2006) are both inclined to picture the Creator as "calling" nature into the future. Just as autocatalysis pulls resources into its own orbit, St. Bonaventure (Delio 2005) conceives of the supreme mutuality of Trinitarian love as calling all of existence into being (and our own beings toward the Godhead). The Alpha and the Omega become one. If God is calling into being from the future, it makes little difference how unappealing the starting point may be, just as the unattractive nature of clay does not detract from a beautiful finished work of pottery.

A More Generous View of Reality

One obvious advantage of a comprehensive account of evolution is that it makes room for and highlights mutuality, the precursor to love. No longer is Social Darwinism the inevitable moral consequence of evolution. The root and drive of all evolution, and even of competition itself, is seen to be mutual beneficence (Russell 1960). It is as if the Creator placed the divine signature on nature as a pale reflection of the love shared by the Holy Trinity

What, then, can we say in summary about a more balanced evolutionary narrative? Here a quick look into history might be helpful. Until the early Nineteenth Century, both science and theology had been molded along Platonic lines – a *conservative* world in which nothing is either created or destroyed, a finished, unchanging natural tapestry. Everyone knows how religion was shaken during the middle of that Century by Darwin's introduction of a *changing* world, and much has been made of the upheaval wrought by the realization that humans likely descended from lesser creatures. Far less ink, however, has been spilled over the simultaneous threat that evolution posed to the then-prevailing scientific conception of nature – initially by Sadi Carnot (1824) with his quantification of an irreversible, non-deterministic thermodynamics and later by Charles Darwin (1859) with his theory of an evolutionary biology. The response of the scientific community to both of these threats was nearly identical – to neutralize each challenge by attempting to withdraw into the comfortable world of conservation and reversibility: Statistical mechanists Ludwig von Boltzmann (1905) and Josiah Gibbs (1901) attempted to reconcile the Carnot's thermodynamics with the Modernist view of a conservative physics. Later Ronald Fisher (1930) and Sewell Wright (1968) employed virtually the same assumptions and mathematics to quantify the eliminative workings of natural selection. These efforts erred insofar as they *ignored* any natural features that did not square with mechanical/material absolutes.

After a brief flirtation by the Church during the middle Twentieth Century to open itself up to the larger natural and social world, the turn of the Millennium unfortunately finds it, too, retreating into a "fortress" of largely medieval theology.

A Call to the Journey

What these parallel conservative movements in both science and religion ignore (at their own peril) are the greater opportunities inherent in a fuller description of evolution – a portrayal of reality neither as a finished tapestry nor as a mindless clockwork, but as a full-fledged, unfinished historical drama between two countervailing cosmic trends. Evolution bids us, both scientist and theologian, to reverse the outcome of the collision between Hebraic and Hellenistic cultures in the centuries immediately prior to Christ. It was then that the Jewish tradition of dialog between humanity and God yielded to the image of a world of pure and unchanging essences, just as in the Greek world the ever-changing cosmos of Heraclitus had earlier given way to the fixed eternality of Plato. It becomes necessary now to recapture the scriptural image of God and humanity in dialog, working together on the continuing creation, and at the same time to reframe the picture of science as being in conversation with the nature it observes and describes.

Such transition can be accomplished only by revamping and reordering fundamental assumptions and discarding false absolutes (Ulanowicz 2011), by placing mutuality (love) ahead of competition, by acknowledging the power of contingencies over law, by listening for and responding to the call from the beyond the material. To be sure, the voice that calls beckons us into strange and often uncomfortable territory. Just as Hebrew scripture favored the nomadic over the sedentary, scientists are now called to cast aside the security of their academic fiefdoms, clerics are called to renounce the trappings of ecclesial power. All are called to walk forward or to perish in place.

Involvement in drama always entails risks. But the plot itself also provides meaning and purpose. The pathway is bound at times to seem treacherous, but the One who beckons also reassures that the traveler is never alone.

Evolution is indeed a glorious drama! It is not to be shunned. Neither is it meant to be constricted by false absolutes, for it is only when seen in its entire breadth that it is able to reflect the fullness of hope.

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