

Animals, Inertia, And Projectile Motion

Or, What is Force?

Sean Collins

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A striking thing you discover when you read Copernicus is that his theory was not complicated. All Copernicus wanted to show was that the planets go around the sun and not around the earth. Not only is this not very complicated, it wasn't even new when Copernicus proposed it. Long before Copernicus, the ancient Greek philosopher Aristarchus had already proposed it.

Still, it wasn't easy for Copernicus to convince his contemporaries to take this idea seriously. But then, this is not really surprising. The most important ideas are often not complicated. Their importance comes from the fact that they are seminal ideas, which serve as principles – not only because many other things follow from them, but also because they form our vision of the world, our way of looking and our way of seeking out the truth – and this especially is why they are not easily accepted.

Today I want to discuss a few such ideas. The thesis I shall propose today began years ago for me as a question. One day during my graduate school years, I was talking with colleagues about Newton's physics. One of my colleagues suggested that Newton's physics was a "mechanist" physics. The understood implication was that this constituted a serious flaw in Newton, on account of which we could not accept his theory. Everyone else seemed to agree that Newton's physics was flawed because it was "mechanistic," and that we should therefore reject Newton and go back to Aristotle. But I confess that this was not my reaction. Mine was to think that I did not know what "mechanistic" means.

A great deal has been said and written about the so-called "mechanization" of the physical sciences, and about how it has reshaped contemporary thought not just in physics, but in everything, from how atoms work to how people think. In some authors there is very reasonable concern that this mechanization has not been a good thing, because it has made us unable to see the order, goodness, and beauty of the world. Perhaps it is even rather an understatement to describe this as just a misfortune; "disaster" might be the more appropriate term.

But however true such claims are, the meaning of this mechanization is not nearly as obvious as it is thought to be, and no moral evaluation of its consequences can be adequately understood until the thing itself is understood. In what follows I am going to sketch out what

I believe this “mechanization” really is and means. Understanding the truth about this may have consequences as far reaching as this so-called “mechanization” itself had.

The seed from which my thesis grows is the observation that it was apparently the introduction of the principle of force into physics which immediately gave rise to mechanization. Therefore if we want to understand what mechanization really is, we must understand the truth about the concept of force, about whether there really is such a thing as force, and if so what it is, and what its relation is to the so-called mechanized physics. I shall therefore begin with a brief dialectical discussion of the concept of mechanism, with particular attention to what force has to do with it.

So what does it mean to say that physics is “mechanistic?” Even the word is puzzling. “Mechanistic” is derived from words referring to machines. But most machines, or at least those we are most familiar with, are not natural entities but artifacts. And artifacts depend, for their working, on the prior working of nature. Therefore to describe nature itself as “mechanistic” appears immediately problematic.

Yet this does not take into account the distinction between higher and lower orders of nature. There seems to be no immediate reason to think that the higher orders of nature might not use the lower ones, much as art uses nature itself, through what we could call mechanisms. Research reveals that this is in fact true, especially in biology; biological organisms do make use of the lower orders of nature – the physical and chemical – through all sorts of “mechanisms.” But what could it mean to propose that this is true not only in the higher orders, but in the lower as well, and indeed at the very heart of nature itself? If the meaning of mechanism is the use of a lower order by a higher, then such a possibility would have to be ruled out.

Yet perhaps this is just the result of giving too much meaning to the concept of “mechanism” as applied to natural processes. Could we not understand it to mean merely that natural processes unfold with blind necessity? Nothing prevents us from giving that meaning to the words, but if we do then questions will remain: can such a thing really happen, is it really an intelligible possibility, and if so, how are we to understand not just the words, but the thing itself? And for what reason does it then seem appropriate to describe that thing as “mechanistic”?

Artificial machines always involve a per accidens subordination of a natural process to a human intention. A car, for instance, is an artificial contrivance which uses the natural process of burning gasoline to move a person from one place to another. Thus what the car does – what any machine does – is subordinate a natural process to an extrinsic end, an end imposed by human intention. From the point of view of human intention, therefore, it is certainly true that the natural process is “blind.” But there is no ground to infer from this that a natural process might be blind and “mechanistic” even within its own order. What a comparison with mechanical artifacts seems truly able to suggest is not that such a thing can happen, but rather that there are different orders to which different kinds of ends are appropriate.

Hence the description of natural processes as “mechanistic” seems to gain no clarification from a supposed analogy with artificial mechanisms. Yet there is no getting around the fact that Newtonian physics did come to be called “mechanistic,” universally and seemingly spontaneously. What was it about the new physics which seemed so spontaneously to make everyone

conceive of nature, as now described, after a likeness to machines? It will make little sense for us to try to judge whether this is good or bad if we don't even know what it is that we are judging.

There may be another way for us to see what the concept of mechanism means, by attending to the way in which disagreements are sustained about whether the physical world can or cannot be mechanistic. There have been many energetic attempts to try to restore a supposedly non-mechanistic physics by trying to reintroduce final causes alongside the principle of force. It is often for this reason, for instance, that physicists and philosophers have been interested in what they call indeterminacy in physical processes. The thinking is that if natural processes are not completely determined by the laws of force, then this indeterminacy might leave room for some things to be determined by final causes rather than by forces. In this view, evidently, physics is called "mechanistic" simply because we forgot that there are final causes in addition to forces.

Others thinkers, however, have gone further. Some, including a fair share of traditional natural philosophers, have tried to argue that force is not a true cause at all. Some suggest that force is really just a symbolic contrivance and not something real. Some say that physics only deals in laws and not in causes. Others say that modern physics is purely mathematical, and therefore has nothing to say about causes. Still others have suggested that it is the origin of forces which is indeterminate, and that it is for this reason that physical processes are able to be subject to final causes.

But none of these claims is adequate, and none of them will finally help us to understand the difference between a "mechanist" and a "non-mechanist" physics. For in the first place it is not reasonable to deny that force is some sort of real physical principle. It presents itself unavoidably in our daily experience as a sort of cause, and this is clearly the reason why Newton introduced it. But on the other hand, if force is a genuine physical principle, and if its agency is not intrinsically subject to any teleological order, then one has admitted the possibility of an account of natural processes which does not, in itself, depend on any order to an end. All attempts to supplement such a physical order based on forces with final causes finally amount to a concession that purpose and final cause are extrinsic to the natural order. And this explains, for example, why intelligent design theory has failed to impress its opponents.

If there are to be final causes in natural things, understood as a genuine principle, they must not be seen as an alternative to agent causality, but as its correlative. The link between agent and final causality must be not just accidental, but essential, for only thus will final causes be intrinsic to natural processes. And so from this we can make a first step in understanding how physics really came to be called "mechanistic." What the word "mechanistic" apparently denotes is a physics which sees itself as having no need of final causes as principles of explanation. But this kind of physics came about not just because we forgot to include final causes, but rather because we have somehow lost sight of how agent causes and final causes are really related.

The question we must pursue, therefore, is why the introduction of the principle of force seemed to make physical processes sufficiently explainable through the agency of forces alone,

understood as having no relation to any final cause. What is it about this principle called “force” which generates this appearance? For all of the historical facts do point to the same conclusion, namely that “force” names an agency to which there appears to be no correlative final cause. That seems to be the explanation for the name “force” itself. In common non-technical English, “force” normally denotes what not only lacks a natural telos, but is even contrary to a natural end: as when we say that something is “forced.” In short, it seems to denote violence. In physics the word has acquired a technical meaning which does not seem to denote violence, but still does apparently denote what lacks any natural order to an end.

But if force is a real agency – and we can have little ground for thinking otherwise – then it is not possible that it have no correlative end. What is possible, however, is that we have not understood what its real end is. If we can discover how its end has remained hidden to us, then we will begin to possess the explanation of how it came to have the peculiar name that it has. More precisely, it seems we must discover how “force” came to denote a cause of motion, but a cause which appeared to have no corresponding telos.

The question being thus clarified, I shall now argue that it has a perfectly clear and intelligible answer, but one which has not been understood until now. My answer to the mystery is that force is indeed a cause of motion, but it is an instrumental cause and not a principal cause.

It is in the definition of an instrumental cause that its end and effect lie outside of its own intrinsic power. The instrument does have the power to produce the effect to which it is an instrument, but it has it only insofar as it stands in subordination to a principal cause. It is in this way, for instance, that St. Thomas explains that the sacraments can be genuine causes of grace. In themselves, the sacraments are just material things, and they cannot therefore intrinsically possess a spiritual power; yet as instruments they can have such an effect, because they have a received power just insofar as they are subordinate to their principal and spiritual cause. In like manner, speech has the power of conveying intelligible thoughts, but not as a principal cause, because it consists of mere sensible sounds which are not capable in themselves of containing thought. But as instrumental causes they can contain and convey thought in a transitory way, through their subordination to a principal cause.

In like manner, I maintain that the thing called “force” does not, by its intrinsic character, have the power to move things in the way that we imagine, but it has it only instrumentally. It acquired its peculiar name, therefore, because it was assumed that whatever it caused, it did so as a principal cause; but then one could not see how it possessed its power of causality in an intentional way, and consequently it came to be regarded as a blind power. This is the short version of the explanation of how physics came to be described as “mechanistic.”

As we shall see, this explains many things. I should like immediately to point out that it explains something which is everywhere in our experience and yet not, for all that, entirely easy to grasp: namely exactly what is going on when we push something. It is a universal and well known principle that an agent must be in act in relation to what the agent acts on. Yet what pushes is always behind, and what is pushed is always what is ahead. But if “pushing” denotes the use of an instrumental cause, then what is behind may possess in an instrumental way, through its subordination to a principal cause, the act which the patient lacks.

But there is another, deeper difficulty involved in the thesis I am proposing. We might recognize this deeper difficulty by posing a question. Given our constant experience of being able to move things by using this thing called force, how can we possibly deny that this effect of moving things is, in fact, quite within the intrinsic power of force itself? Or we might put this question another way. What do we, animate beings that we are, give to force that it doesn't already have, so that it can become an instrumental cause?

The only answer I believe there can be is this: what we give to force is an intentionality towards an order of place, which order exists only in relation to ourselves. That is how we make force into an instrumental cause. Animate beings use the thing call force as their proper instrumental agency, for moving both themselves and their effects, according to what they recognize as an order of locations which pertains to themselves as such, as animate beings. However self-evident it may seem at first, this animate order of location and local motion is not self-evidently the same as an order of location and movement for inanimate bodies in the universe at large. And if we pay modern physics the attention it deserves, we shall find that this distinction is not only a possible one, but a very real one, corroborated by a great deal of physical research.

But of course these are challenging distinctions to make, both on the level of general philosophical considerations and on the level of experimental investigation. Philosophically, the challenge is to see how there can be, in a way, more than one order of place. Or, to put it another way, the challenge is to see how the identity of place is not so simple as it first seems. In the order of apprehension, it is natural for us to see things at first in a relatively unconcretized manner, and at that stage of knowing, there is always a risk of overidentifying what we conceive abstractly with what concretely exists. Consequently, we may easily but incorrectly infer that because place has one definition, it also can have only one mode of concrete existence. It belongs especially to experimental science to correct this mistake, by concretizing our abstract understanding of place. But on the level of experimental science, there are various circumstantial impediments to understanding as well. The principal ones are the classical Newtonian concept of space (which is itself the result of a misplaced abstraction), and the positivist account of science which arose in the late 1800's. It must be at least in part the role of philosophy to correct these impediments.

Historically, what has been unfortunate is that many traditional natural philosophers have shrunk from these challenges altogether, not sufficiently understanding in the first place what was needed, and often thinking that the better strategy was simply to try to demote scientific investigation to a realm of uncertainty where it would pose no threat. To do this they have frequently made themselves unwitting accomplices in the positivist deconstruction of experimental science, not recognizing that the true opponent was radical positivism itself. A true solution to the challenges at hand is achievable not by separating natural philosophy from science, but rather by bringing them together and letting them assist each other. Remarkably, it is Newton's Laws which can provide us with some of the first critical keys to a clearer view about the truth concerning the meaning of force. More recently, the theory of relativity and also the quantum theory have shown how to find still greater clarity, providing one knows how

to interpret these theories outside the strictures of radical positivism.

Newton's Laws

So now let me now turn to Newton's Laws, and the Third Law to begin with. There are reasons to be puzzled about Newton's Laws, and about the Third Law in particular. For the Third Law says that to every action, there is an equal and opposite reaction; or to be more blunt about it, to every force there is an equal and opposite force. But if forces are what move things, how could this be? If two people have an Indian wrestling match, how can the forces always be equal and opposite if one person is to prevail over the other? Or what happens in a tug of war?

Newton was not unaware of this problem. He proposes a well known solution, which is that we must make a distinction between what forces are from and what they are on. He suggests that when a horse pulls a cart, for instance, there are equal and opposite forces in the rope, but one of them is a force of the horse on the cart, while the other is a force of the cart on the horse. And so, Newton says, if we want to understand how the cart moves, we should not include those forces which are from the cart, but only those which are on the cart; and if we make this distinction, we find that the forces on the cart do not just add up to zero. This is the solution which is still taught to physics students even today.

But the solution itself is quite plainly problematic, because it says, in effect, that the equal and opposite forces are only mathematically opposed, and not physically opposed. And so if we hold to this solution, we must conclude that there is no conflict whatsoever entailed in the forces that the Third Law describes. This appears to be contrary both to our manifest experience, as in the example of a tug of war, and also to how Newton himself describes the matter at other moments. For one thing, Newton often speaks of resistance to forces; but there will only be resistance among forces if they enter into conflict somewhere. For example, if one horse tries to pull the cart backwards, while another tries to pull it forward, both forces are certainly on the cart, and so we might imagine that one is as resistance to the other. But if this is to be true, then these forces must come into conflict somewhere. This of course is just what happens; the forces do apparently come into conflict, namely in the cart itself, in the form of what we call tension. If the tension is great enough, it may even destroy the cart. Hence it appears as if there is no alternative but to say that there is real conflict in precisely the situation that the Third Law is describing, namely the opposite forces at a point which the law describes. Yet surely it will not do either to imagine that the forces are only approximately equal and opposite.

The real solution, however, is to recognize the significance of the thing we are calling tension. When we begin to think about force in light of our experience, we quite naturally think of it as existing just at the surface between a mover and what is moved. But what we have just been describing illustrates that this is in fact not true. In reality, it exists throughout what is acted on. Physicists recognize that in fact it normally exists as a wave which travels through the object which is acted upon. It also turns out to be not strictly speaking just the tension in

an object, but rather a tension gradient, that is, a continuous change of tension from one place to another, which results in movement. And whereas the tension is envisioned by Newton as consisting of equal and opposite forces at each point, the tension gradient may nevertheless have a determinate direction; that is, the tension may be continuously increasing or decreasing in one direction or the other. The parts of a body, as it turns out, naturally accelerate from the places of higher tension towards those of lower tension.

Although this may seem to suggest more questions than it answers, it at least strongly suggests what turns out to be a decisive turning point towards a solution to our difficulties. We can see that the thing Newton decided to call force is, in its concrete physical reality, really a tension or a compression. Newton was in search of the most universal or generic agency of local motion, and this is what he found. Many things in what appeared to be no more and no less than common experience induced Newton, and nearly everyone after him, to suppose that this was indeed the cause of motion that had been sought. But in light of our earlier discussion of force and instrumental causality, perhaps you can already see the missing distinction. In reality, tension does not have two local directions, a this way and that way, except insofar as it becomes an instrumental cause. The tension in the rope between the horse and the cart, for instance, becomes an instrumental cause for moving the cart forward. If the cart were not a cart but a recalcitrant donkey, then that very same tension could become, at the very same time, an instrumental cause for moving the horse backwards. In other words, Newton never considered the potential implications of instrumental causality, and consequently assumed that whatever this tension did, it did it as a principal cause. The inevitable inference, then, was that it must resolve into a pair of equal and opposite pushes or pulls. What Newton and those after him couldn't see is that the reality is just the reverse: not that tension or compression resolves into equal and opposite forces, but rather that the thing called "force" is, on the physical level, nothing but tension or compression: an agency which is not inherently in this local direction or that, but rather inward or outward. In short, we must understand that tension and compression are not in essence agencies towards changes of place, but rather towards changes of quantity. They are distensive agencies and not locomotive agencies. Once we grasp this, it becomes easy to understand the meaning of the Third Law, and how it can be perfectly true. We may note some irony, then, in the fact that Newton both did and did not understand the Third Law.

We can now see more concretely, therefore, how the thing called force acquired its peculiar name. It did so because a power was attributed to it towards which it was vaguely recognized as not being able to possess its own intrinsic intentionality. And this is the reason why, upon the introduction of force as a principle into physics, physics immediately lost its teleological basis.

I would like to give you another remarkable and concrete illustration of what I have been saying so far, by looking at another passage in Newton's *Principia*. Right after setting down the laws, Newton has a Scholium in which he tries to show how the laws are verified in experience. When he comes to the Third Law, he proposes what he takes to be an empirical proof of the Third Law in the case of attractive forces, from the fact that bodies which attract and consequently press upon one another do not, as a result of the forces involved, migrate to the

side of one body or the other. “So,” he writes,

the gravitation between the earth and its parts is mutual. Let the earth FI be cut by any plane EG into two parts EGF and EGI, and their weights one towards the other will be mutually equal. For if by another plane HK, parallel to the former EG, the greater part EGI is cut into two parts EGKH and HKI, whereof HKI is equal to the part EFG, first cut off, it is evident that the middle part EGKH will have no propension by its proper weight towards either side, but will hang as it were, and rest in an equilibrium between both. But the one extreme part HKI will with its whole weight bear upon and press the middle part towards the other extreme part EGF; and therefore the force with which EGI, the sum of the parts HKI and EGKH, tends towards the other part EGF, is equal to the weight of the part HKI, that is, to the weight of the third part EGF. And therefore the weights of the two parts EGI and EFG, one towards the other, are equal, as I was to prove. And indeed if those weights were not equal, the whole earth floating in the non-resisting ether would give way to the greater weight, and, retiring from it, would be carried off in infinitum. (pp. 25 – 26).

I hope you find this passage as amazing as I do. Newton’s conclusion here seems perfectly reasonable, but his interpretation of the conclusion is not nearly so obvious. He speaks here according to what we could take to be a prescientific account of how things are moved. When he writes that “the one extreme part HKI will with its whole weight bear upon and press the middle part towards the other extreme part EGF,” we can easily conjure up images of a sort of inanimate Indian wrestling competition, in which HKI is battling with HKF for victory, and we wonder which one will win and which one will lose. It is surprising enough that Newton would describe the picture this way, because we know after all that he is at this very moment in the process of arguing to the Third Law, in which the absence of winners and losers seems to be an unavoidable result, not only by accident but in principle.

But if such a seemingly crude prescientific account from the pen of the master Newton is not already surprising enough, we may wonder further about it when we realize that there cannot be, according to Newton’s own laws, just two equal and opposite forces across each of the planes EG and HK, but that there must be rather four; for at each plane, there is a pair of attractive forces as well as a pair of pressure forces. This complicates matters still further, because we must then wonder how the pressure forces are related to the attractive forces. And what are these forces really aiming towards? Are we accurately describing the reality if we imagine that the attractive force of EFG upon EGHK, for instance, aims at causing EGHK to migrate indefinitely towards the side of EFG, even beyond where EFG itself stands? And is this the meaning of the pressure of EGHK upon EFG – that it’s trying to go past EFG and take EFG with it? Such things seem implausible, to say the least. Yet if we understand the agency involved to be something called “force”, with no identifiable intrinsic telos, then Newton has said no more and no less than what he must say.

Newton concludes his argument by saying that the two parts EGF and EGI are in a state of

equilibrium. “And indeed,” he writes, “if those weights were not equal, the whole earth floating in the non-resisting ether would give way to the greater weight, and, retiring from it, would be carried off in infinitum.” Newton is thus implicitly granting, at least for the sake of this argument, that the equal and opposite forces of which his Third Law speaks really do enter into a conflict, in which it may happen, as in this case, that there is a stalemate or equilibrium. But finally it is not a plausible interpretation to suggest that the earth remains at rest, rather than migrate to the one side or the other, because of an equilibrium between opposite tendencies. The far more plausible interpretation is that opposite locomotive tendencies inclining indefinitely far to the one side or the other are here not balanced, but rather simply non-existent.

You can see that the difficulties of interpretation Newton encounters here are really just the result of trying to attribute to so-called forces an intentionality which they don’t have of themselves. He makes that attribution because he takes our experience of pushing and pulling, in which tensions and compressions are made into instruments of local motion, as representing accurately what the physical tensions and compressions are in themselves. And because he attributes to inanimate things intentions which really belong to the animate use of them, Newton can give no determinate end to those intentionalities. He is therefore constrained to say that they tend in infinitum, to use his own words. But ironically, as was noted already, Newton’s Third Law in itself suggests a completely different, and much better, account of what force truly is, namely a distensive agency with the wrong name attached to it.

I must now turn to the rather more challenging difficulty which underlies the confusions we have been examining. As was suggested already, the greatest reason why it is so hard to see the instrumental nature of force’s locomotive power is because this inevitably entails a deeper examination of the concepts of place and local motion themselves, so that we can see that there can be different orders of place. In this connection it is going to be necessary to say something about Newton’s First and Second Laws, which bear upon this more fundamental matter.

The first thing to be said about this is that the concept of space, in its full Newtonian articulation, forecloses ever coming to a deep understanding of these matters; for it reduces all physical concepts to mathematical ones, among which teleology and instrumental causality can have no place; and moreover it lodges this mathematics in an undecipherable entity called “space,” which we must then resign ourselves to simply using with no further account.

But on the other hand, one must often be cautious, as the saying goes, to avoid “throwing the baby out with the bath.” There is abundant evidence that Newton’s concept of space, flawed as it may be, bears a likeness to reality. Unfortunately I do not have time to discuss this at length. But what I shall do now is turn to Newton’s other two laws, and look at them via the concept of inertia. This will take us back to the more fundamental concepts of place, and of motion understood as a kind of act or ἐνέργεια.

If a student finds the concept of inertia puzzling, he may find comfort in the fact that Newton apparently did too. Evidence that he wonders about it is that he discusses what name to give it. In fact he gives it two names, of which one seems to be paradoxical if not an outright contradiction. The first name he uses is *vis insita*, or “innate force.” But is inertia really a force? In a mysterious

passage, Newton concludes that this *vis insita* really only acts when one body encounters resistance from another body, and the action itself consists of the more ordinary, impressed force. Newton consequently decides to refer to the *vis insita* by its other name, *vis inertiae*, or “force of inactivity.” If we should happen to be puzzled about what in the world “force of inactivity” could mean, Newton obliges us only by describing this as a “most significant name.” What that significance is, exactly, he leaves us to surmise for ourselves. The fact is that Newton did not understand this, and he knew he didn’t understand. His own enormous effort to understand it finally eluded him.

In fact we find in the opening pages of the *Principia* an even more striking paradox than the one signified by the phrase “force of inactivity.” Because of the presence of this thing called inertia, it becomes hard to distinguish between bodies which are at rest and bodies which are in motion. We encounter this difficulty even in direct experience. In a subway, the experience of moving forward while the car next to you remains at rest can be absolutely identical to the experience of remaining at rest while the other car moves backwards – to the point where you can’t tell which is really happening. On an airplane, the flight attendant moves her cart from the front to the back of the airplane in a manner which seems to betray complete indifference to the fact that the plane is moving or not moving. On a larger scale, we play baseball and ping pong, and waiters deliver trays of drinks to customers, in a manner which betrays brazen indifference to fact that the earth is supposedly hurling around the sun at a speed of 95,000 miles per hour. Historically, of course, it was the strangeness of this very thing which became a central point of contention between Ptolemaic and Copernican astronomers.

But while this difficulty has always existed at least on an experiential level, Newton raised it to a theoretical level. Newton knows that it is not easy to tell what is moving absolutely and what is not. He knows it so well that he even says, at the conclusion of the Scholium to his *Laws*, that his very purpose in composing the *Principia* is to finally show what in the cosmos is absolutely in motion and what moves only relatively. Yet only a few pages later, he demonstrates his Fifth and Sixth Corollaries to laws, which entail the consequence that this purpose can never be accomplished, not only in practice but even in principle.

Newton held that all local motion takes place against the backdrop of absolute space. Postulating the existence of absolute space was Newton’s final recourse to defend his claim of absolute motion. But the postulate itself amounted to a gratuitous and problematic hypothesis, which even Newton’s own laws apparently belied. A major source of the difficulty was this very principle of inertia, which makes inertial motion appear to be so identical to rest that that finally one cannot tell which is which. Still, physicists resisted, for as long as they could, the conclusion that these really were the same thing. Their resistance finally collapsed in the early 20th century, when they received no cooperation from the only possible remaining recourse against that conclusion, which was the phenomena of electromagnetism and light. For it turned out that even light, a wave capable of traveling across immense stretches of open space, travels with an absolutely fixed speed not relative to that “space” itself, but relative to the bodies in space; and it maintains that fixed speed in relation to all bodies, no matter how the bodies happen to move among themselves. This was the death knell of the concept of absolute space. But it isn’t just

hardcore Newtonians who found it unacceptable; some traditional philosophers find it doubtful too, because it seems to them to be impossible that there could be relative changes of place, and especially this kind of relative change where velocities don't seem to add in any rational way, without absolute changes of place. But what is overlooked is that space itself is mutable.

The word "place" is used in many analogous ways, but they always involve situating something within an ordered whole. One may speak for instance of the place of a person within a corporation, or the correct place of a premise in an argument, or the place in which a runner finishes a race. But we can also notice that the places of things, especially in the most literal physical meaning of place, involve a fundamental quantitative order, upon which a qualitative and substantial order is superimposed. When we distinguish "up" from "down," for instance, we are distinguishing places which are qualitatively different; but before they can be qualitatively distinct, they must be quantitatively distinct. Aristotle accordingly suggests that place must be understood most fundamentally in terms of containment. The body which is in place is related to its place as to a container, and this containment is fundamentally a quantitative relation.

If the order on which natural place depended were purely qualitative or relational and not quantitative, there might be different kinds of places for different kind of beings, since many such orders can exist simultaneously. For example, I can (analogously speaking) have one place in the order of a committee, and another place in the order of my country. And thus animate beings as such could be conceived as essentially subject to a different local order than inanimate beings. But if the fundamental order on which physical place is based is quantitative, it seems at first that this is impossible. There seems to be only one quantitative order of the cosmos, and hence it seems that the local order of place cannot be different for animate beings than for inanimate ones. Ultimately it is this apparent necessity which has been responsible for the assumption that if force is the principle of animate motion, it must be the principle for inanimate motion as well. But Newton's Laws were the first move away from this view, and relativity completed the move.

Aristotle argued that we must understand place in terms of containment; but furthermore, he suggested that it is the outer container which is most formally determinative of the place of a thing, whereas the inner part of the container is more material and instrumental. Thus a boat anchored in a river keeps its place even as the water flows around it, because its relation to the banks of the river stays the same; but on the other hand a boat coasting downstream changes its place, even as the water immediately surrounding it stays the same.

In addition to this, Aristotle claimed, reasonably as it seems, that place has a certain power over bodies. He no doubt had in mind especially the apparent power of the up and the down. Hence one would easily conclude that there is some intentional relationship, even a powerful one, between bodies in place and the whole quantitative order which is the principle of their place. This indeed is part of the line of thinking through which Aristotle was able to make a decisive break from his predecessors. They had conceived of mobility as essentially the same thing as mutability, which in itself would be nothing but otherness and non-being, and therefore not a suitably intelligible object for science. But Aristotle thought he saw reason to hold that motion, and in particular motion with respect to place, is not mere change, but a genuine being, an *energeia*, subject to intelligible powers and causes. That thought lay indeed at the very foundation

of the new science called physics.

But now let us put these thoughts alongside the remarkable discoveries of modern physics. Light was long thought to be instantaneous in its passage from one place to another. This turned out to be false, but it is not false that light is astonishingly fast. In the couple of seconds it takes me to utter this sentence, light could go around the entire earth about 15 times. Nevertheless, the size of the universe is so vast that even light takes something in the order of 14 billion years just to traverse it. Given this mind-boggling magnitude, there is reason to wonder exactly what it can mean for an object in our universe to maintain one place, one intentional relation to the whole, understood as an act... or, on the other hand, to undergo an act of movement by changing that relation to the whole. If I roll a ball across the floor, is it plausible that that the act of motion of the ball, brought about by my gentle hand movement, is defined by an essential relation to this whole immense quantitative order? Or if it is not plausible, what exactly is the alternative?

Any adequate answer to these questions must be based on Aristotle's own observation that the mode of existence of quantity, upon which place depends, is not the same in physical beings as it is in mathematical beings. In mathematics quantity has its being through an act of thought, so that it has an essentially different sort of wholeness than it has in the natural world. In a sense we could say that mathematical beings are eternal, because the existence of a mathematical magnitude is entirely independent of temporal conditions. It is also independent of qualitative conditions. But in the physical world, this is not true; there is an interdependence in the physical world between the existence of the quantitative order and the substantial and qualitative orders of perfection which come after quantity. Hence it appears not in the least impossible that different kinds of bodies – the animate and the inanimate in particular – should have essentially different relations to the quantitative order of the whole – or rather, indeed, that there are different wholes to which they are by nature locally related. What animate beings such as ourselves identify as one place can therefore be very different from what an inanimate body, such as a planet, has as its one place. The history of astronomy, from Ptolemy through Einstein, can in retrospect be seen to be in a way about this very question.

Gravity, as Einstein finally realized, is not a force, but both a temporal and quantitative configuration of space, and it depends on the bodies in space, particularly on their quantitative characteristics and the agencies inherent in bodies by which those quantitative characteristics are modified. Hence in the theory of general relativity, the inanimate order of place is one for which it turns out that inanimate bodies are themselves responsible, through the imperfect quantitative being of gravitational space. At last we are therefore able to see what to make of Newton's mysterious intuition that the so-called *vis insita* should also be called "inertia," or a "force of inertness." What general relativity says is that inertial motion really is inert, that is, it is really not motion of the inertial body itself at all, but rather a local stasis of the inertial body in the imperfect and radically mutable body which we call "space." This, finally, is the meaning of the principle of relativity, which was itself a deeper interpretation of the principle of inertia.

This implies that Newton's account of force and inertia was backwards. Newton tried to understand inertia as a force, a power bodies have to engender or sustain motion through the intermediary of impressed force, and he tried to see the latter as the true immediate source of motion.

This was in keeping with what is mistakenly taken to be our common experience of how things are moved by pushing or pulling. What Newton could not see, however, is that the order of place according to which force is by its essence an instrumental cause of movement is not the same as the order of place according to which bodies are located in space.

We can now, therefore, make much more precise distinctions than we have made so far about how force is and is not a real cause. In addition to the distinction between instrumental causes and principal causes, we must also distinguish between what essentially defined as a cause and what acts as a cause but not by its essential definition. It is clear, for example, that a hand or an eye is, by its very essence, a cause both ordered to, and capable of achieving, some end: in the one case grasping things, and in the other seeing things. But there are also natural entities which may apparently act as causes, without that being what properly defines them; and the reason for this is because they become natural causes not by their being ordered to some end, but rather by some other natural entity being subordinately ordered to them as to an end. Thus natural substances, for example, may be the causes of the accidents which inhere in them, but more by a natural subordination of the accident to the substance than the reverse. Or, again, natural beings higher in the scale of perfection are causes of those which are lower; for example, animals and plants are causes of various molecular structures such as enzymes and DNA, which latter exist for the sake of the animal or plant. There must be an agency in the animal or plant which brings these molecular structures into being. But the causal ordering and orientation exists in the lower by definition, and not the higher.

To be very precise about “force,” therefore, we should say the following. In its natural essence, it is nothing but the natural agency in bodies by which they maintain their size; it is this that we are calling tension (or whatever the opposite to tension would be, in a body which is compressed: an agency tending to make a body extend itself). But this agency, and more generally the dimensive characteristics of bodies to which this agency pertains, are all causes of the dimensive characteristics of space as well. But they are not causes of this spatial configuration in their definitions; they are rather the higher beings to which space is teleologically subordinated. Hence tension does not “move” things as if that were its own intrinsic telos; yet it does contribute to the formation and constant modification of gravitational space, not by being ordered to so doing, but by gravitational space’s order to bodies.

The appearance of “motion” in the physical world, therefore, is a far more subtle and interesting thing than those natural philosophers imagine who are still attached to an antiquated world view. There is, to be sure, a mutation constantly occurring in the gravitational ordering of space. And, to be sure, in the midst of this mutation there is also an act which is that whereby physical bodies order themselves locally. Hence we can begin to have a far more concretized view of the fundamental intuition through which Aristotle began to see a distinction between motion and mere mutation, and thus the possibility of a science of nature. But this act is not, as the natural philosophers imagine, an act whereby a body tries to get itself from here to there in an essentially immutable order of space.

There is, however, another order of place to which tension is ordered: not by its essence, but by an extrinsic imposition of an end. This is an ordering either by human art or by animate in-

tention. Because this distinction between two orders of place was not understood by Newton and his successors, tension came to be called “force,” as if it had an essentially definitive ordination to moving things; yet since it was impossible to see the nature of that ordination, it was, as it were, affirmed and denied at the same time. One held that local motion was indeed what forces accomplished, but one could not see how they accomplished it as a genuine telos.

General relativity shows us, then, how to see gravity as a configuration of space itself, and this is, by all the evidence, the true universal locational order of bodies on the inanimate level. But this gravitational order also lacks the stability which higher beings require to sustain and perfect their existence, and therefore it is not the same as the order of place which we discover most readily through our daily experience.

The so-called mechanization of nature was, therefore, the result of a misunderstanding of our experience of pushing and pulling, in which the intentionality proper to inanimate agency is confused with that of the animate agency to which the inanimate serves as instrument. The result of this confusion was that the thing we call “force” appeared to have no intrinsic telos, and was named accordingly. It is thus no accident that this “mechanization” is named by a word taken from the world of human artifice – not because, as is often supposed, a mechanical universe is one in which embedded artificial mechanisms are the explanations for everything, but rather one in which we have inadvertently developed the habit of portraying the telos of natural activity to ourselves as if it were like that of the machines we make: extrinsic, that is, to the natural agency itself. Neither is it an accident that the “mechanized” world is one where neither the natural nor the violent seems to be an appropriate category; for when the telos of natural activity is inadvertently made extrinsic, on account of a confusion of different orders of causality, it becomes impossible to make the distinction between the natural and the violent. And this, moreover, made it falsely appear in the end as if agency and telos really had no essential connection with each other.

This false appearance is not just characteristic of Newtonian physics. The image of moving something by pushing it is a paradigm in terms of which even traditional natural philosophers have long been accustomed to thinking about motion, agent causality, and final causality. But the paradigm is all too readily misinterpreted. Newton himself did no more than formalize both the image and its usual misinterpretation, into a fully articulated paradigm, even as he began to apprehend some of the principles through which it would finally become recognizable as defective. If the metaphysical implications of this paradigm are enormous, the correction of it, through the combination of both philosophy and modern physics, may have even deeper implications.