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Some Considerations on Aristotelian Place and Newtonian Space

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Most Catholics agree with most non-Catholics that the scholastic philosophy, especially the scholastic physics, by means of which much of the Church's doctrine has traditionally been expounded, has been wholly discredited by modern science. They see that modern science has extended our understanding of nature and given us a control over nature not even imagined by the older philosophers, and that many assumptions of modern science are incompatible with the ancient philosophy of nature—and they draw their conclusion. They are right in some ways. There really are disagreements in principle here, and the scholastics certainly got some things wrong. Yet if we leave the question in this state, we are surely, as Catholics, in a curious state. We recite a creed in which the Son is said to be "consubstantial" with the Father; we speak of the Eucharist in terms of the "accidents of bread and wine" and the "substance" of Christ; we talk of the "form" and "matter" of the sacraments; of a "natural law;" of God as the "First Mover" and even as a "cause of being." All these notions find their most complete development in scholastic physics and metaphysics. If that philosophy of nature and the metaphysics based upon it are completely wrong,

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the theological grasp of matters of faith through the language of that philosophy is impossible, for modern science is surely not concerned with such notions, but rather with mathematical formulae which reflect nature in some way, often a very remote way. A more exact analysis of the method of modern physics would lead us to conclude that it has nothing to say about these things, positive or negative. I will not go into this method in detail here, but it is useful to recall what one of the chief exponents of modern science, Henri Poincaré, had to say about how modern science treats even those things which in some way fall within its scope:

> When one says that force is the cause of a motion, one is doing metaphysics, and this definition, if one must content oneself with it, will be absolutely sterile. That a definition might serve some purpose, it is necessary that it teaches to measure force; moreover, this is sufficient: it is in no way necessary that it teaches us what force is in itself, not even whether it is the cause or the effect of motion.
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> . . .even if this direct intuition [arising from the notion of effort, which is familiar to us from infancy] makes us know the true nature of force in itself, it will be insufficient for the founding of Mechanics; it will be, moreover, totally useless. What is important is not to know what force is, it is to know how to measure it.[1]

If this is right, one could hardly think of using modern science as a replacement for the older philosophy of nature, of basing theological thought on the theoretical structures built around operational definitions of force, mass, light, etc. Such definitions are not about what these things are, let alone what a substance or a good is.

What, then, are we to base our theology on? If we think that we can turn to the evident truths about things,

[1] Henri Poincaré, *La Science et L'hypothèse*, (Paris: Flammarion, 1968), pp. 118, 124.

causes, goods, etc., we are in fact turning to the very foundations of scholastic natural philosophy. But there is really no choice to be made: the doctrines of the Church are already formulated in terms drawn, in large part, from the common sense upon which ancient natural philosophy is based.

> The facts testify that the Church, in the Ecumenical Councils held after his (St. Thomas Aquinas') death, so used his writings that many of the decrees propounded found their source in his works and sometimes even the same words were used to clarify Catholic dogmas or to destroy errors.[2]

If that physics is so far from truth as most people think, we are left saying the Catholic Church has utterly misrepresented the truths God has given her the exclusive and infallible ability to define. This is not, of course, to say that everything the ancients said about physics is right or that everything the moderns say is wrong. It is only to insist that there must be something essentially right about the scholastic procedure and central insights.

Now, the Church clearly sends us to St. Thomas Aquinas as to the master of philosophy and theology. In *Aeterni Patris*, Pope Leo XIII quoted Pope Innocent VI as saying:

> His teaching above that of others, the canons alone excepted, enjoys such an elegance of phraseology, a method of statement, a truth of proposition, that those who hold to it are never found swerving from the path of truth, and he who dares assail it will always be suspected of error.[3]

Moreover, when Pope Pius X sends us to the scholastics, he leaves no doubt that St. Thomas is first among unequals:

[2] Pope Pius IX, Letter to Fr. Raymond Bianchi, July 9, 1870.

[3] Pope Leo XIII, *Aeterni Patris* (1879), (Boston: Daughters of St. Paul, n.d.), p. 16.

> When we recommended that the philosophy of Aquinas "particularly" but not "exclusively" be followed, some persuaded themselves that they were acting in conformity with Our will, or at least not actively opposing it, in the indiscriminate adoption of an adherence to the philosophical opinions of some other Scholastic doctor, though they be repugnant to the principles of St. Thomas. They were greatly deceived.[4]

It is clear, though, that St. Thomas' philosophy of nature is derived from Aristotle's, and so I would like to concentrate here on Aristotle's thought. As I said, I do not wish to give a detailed critique of the method of modern science; instead, I would like to compare Aristotle and the moderns as to certain general points of procedure, and try to show the consequences of embracing the modern mode without qualification. To do this, I will take Newton as a spokesman for the modern mind, for he focuses in a remarkable way some key strands of modern thought.

Furthermore, our idea of place is a locus of our thought about other matters, both physical and theological, so I will start with Aristotle's and Newton's views of place. We everywhere see signs of the importance of place in our thought: we speak of the "place" of a concept in a system, of a person in a family, of the family in the state; we speak of God being "everywhere," and the universe being "nowhere" or "in itself;" we speak of "where" we are in time or our careers; of a species being "in" a genus; etc. The universality of our image and notion of place even led Kant to posit space as a form of consciousness, i.e., an attribute of our minds which determines the way we sense the world. More proximately to physics, it is clear that the way we understand things to be in place will to a

[4] Quoted by Santiago Ramírez in "The Authority of St. Thomas," *The Thomist*, 1950, (pp. 1-109), p. 63.

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large extent determine how we think of the order of the universe. I hope to manifest more fully in the third part of this paper how the conception of place is tied to our understanding of other aspects of the world.

This paper will be divided into three parts. In the first and second parts, I will present Aristotle's and Newton's views and something of their backgrounds; in the third, I will attempt to outline the significance of the differences uncovered in the first two parts.

I
Aristotle's View and Its Historical Background

The Pythagoreans, believing that numbers, thought of as points, constituted things, rightly considered that such numbers must be separated by empty space. For, as Aristotle says, points cannot be multiple and touching. They must be separated, and, since all beings, according to the Pythagoreans, are made up of these point-numbers, they must be separated by non-being, i.e., by empty space. The Eleatics, led by Parmenides, responded by saying that what is not, is not, and what is, is. By denying the existence of non-being, they were constrained to deny the existence of multiplicity and of motion, for both imply difference and difference implies non-being (this is not that). The immobility of the All is a direct consequence of denying the existence of the non-being needed for difference. For example, if there is no difference between white and black, one can hardly change from one to the other. Hence the famous, or infamous, doctrine of Eleaticism: "The All is one and motionless."

Faced with this, certain later philosophers tried to explain our experience of motion and difference while retaining the doctrine that what is, is and what is not, is not. Some, called pluralists, posited a multitude of beings, each

of which is, in a sense, one and motionless. Thus Empedocles speaks of earth, air, fire, and water as being primary unchanging elements of things and Anaxagoras posited an infinite multitude of "seeds" in every perceptible body. For example, in a piece of wood there would be seeds of fire and of ash and of smoke. What occurs in burning is only their separation. The Atomists Democritus and Leucippus say something similar but are, it seems, more rigorous. For they saw that even the separation imagined by the pluralists involves non-being, since it is change of place. Locomotion cannot occur unless places are different, so locomotion implies non-being. Hence their audacious claim that what is not, is. This non-being they called "the empty" or "the void." They do not try to "get around" Parmenides, they simply deny his basic premiss.

A friend of Plato, Archytas of Tarentum, also argued for a void space. His famous claim that the existence of void space is manifested by imagining a javelin-thrower placed at the edge of the universe has been repeated throughout the centuries. He claimed that place and matter are distinct, for bodies must exist in place but place can exist without bodies. Since all else needs space while space does not need anything else, place might be the first of all beings. In discussing Hesiod's similar view that place is prior to body, Aristotle predicts that those who believe this will make of place a marvelous thing of great power. This prophecy will be fulfilled in Newton.

Plato makes of place some sort of matter, according to Aristotle. "As place seems to be a dimension of magnitude, it is matter; for this is different from the magnitude. It is what is encompassed and defined by the form, as by a surface or limit. Matter and the undetermined are of this sort. For whenever the limit and passions of a sphere are removed, nothing besides the matter remains. Because of this, Plato says that matter and space are the same in the

Timaeus."[5] The argument seems to be that, if one thinks of place as the dimensions underlying a body and then removes, in thought, the "passions" of the sphere, i.e., its colour, weight, and other sensible qualities, as well as its "limit," i.e., its shape, one is left only with the underlying dimensions. These dimensions are not the same as the magnitude of the sphere, for these dimensions are, as it were, cut off and defined by the form in order to produce magnitude. The shape determines these dimensions of magnitude, so that the dimensions are material with respect to the shape. Moreover, there is an analogy between space and matter—both receive, one bodies and the other forms. And as the forms are present in this world, according to the story of the *Republic*, as if by projecting their likenesses onto a cave wall in a shadowy form, the receptor of these forms is like matter; and it is the extension or dimensions of the wall. When we recall that void space was originally posited to account for motion and individuation, just as Aristotle says matter accounts for these,[6] we begin to suspect there is more at work in the Platonic view than an overly active fancy.

In fact, both motion and individuation suppose difference, as we have seen. Now, the Atomists and Pythagoreans posit particular substances ("atoms" and "monads") as "being" and what is between these, space, as "non-being." This space, then, is seen as absolutely other from being (identified with body), and is thus the root of being other. Motion, which is becoming other, also finds its roots in this same non-being. Thus individuation and motion arise.

The conception here is that being is localized and non-being is locale. For the mind unable to grasp non-imaginable things, or apt to confuse what it imagines with

[5] *Physics* IV, 2, 209a6-17.

[6] *Physics* I, 7, 189b30-191a22; Metaphysics VII, 10, 1035b27-30.

what it conceives, the notion of place as non-being is very natural. We think of bodies as being, and when we want to think of the negation of being, we remove the body in thought; what is "left" is the place from which we removed the body. This place, then, becomes identified with non-being. Our everyday speech also underlines this tendency of thought: we say "there is nothing in the room," meaning that the visible and tangible bodies with which we tend to identify being are not there. And to indicate real existence, we use the idiomatic "there is. . .," as if being is what can be in place, i.e., body; by contrast, non-being would be non-body, most readily, though erroneously, identified with "empty" space. The French use the similar expression "il y a. . . ."

In contrast to the Atomists, Plato identifies non-being with something in a body, the matter, not with what is outside of the body. To'the extent that Plato identifies space with non-being, he is saying what the Atomists and Pythagoreans said, but in saying that space is matter he has made non-being an intrinsic component of sensible being. Why would he do this?

The most famous of Plato's doctrines is that of the "Ideas" or "Forms," incorporeal natures which are the foundations of knowing and of being. Noting that we have a single name, e.g., "man," for a multitude of individuals, and that true knowledge is of what is always the same, e.g., every triangle always has three angles equal to two right angles, Plato drew the conclusion that the things around us are known and named by reference to eternal "Ideas." By being eternal, these Ideas account for the eternity of knowledge; by being singular entities in which a multitude of sensible things "participate," they account for the unity of our notion of that multitude.

These arguments confuse the mode of knowing with the mode of being. Basically, Plato is saying that because

things are unified and eternal in our minds, they must be unified and eternal in themselves. We might think the identity of these modes is necessary, thinking that if they are different we do not know things as they are in reality, i.e., we do not know them at all. This is a difficult problem, but for now we must be content to notice that an overly simple application of the principle that we know things, if we know them at all, as they are, leads to certain absurdities. If my knowledge that my son is in the next room is caused by my hearing his voice coming from there, it would follow that the reason he is there is that I hear his voice coming from there.[7]

Now, if we make Plato's assumption, we say that whatever is true about a sensible thing is true of it due to its participation in an intelligible reality. We relocate being in a supra-sensible realm. What we have left here below is only a shadow on a wall. More precisely, whatever it is in sensible things that receives the intelligible Ideas is itself not an intelligible Idea; moreover, it can have no name or nature (since whatever does is eternal and unified), and so is utterly other than the intelligible. Thus, Plato makes what is in things, what participates in the Ideas, non-being. Since what receives the form or nature is matter, e.g., the clay receives the shape of the statue, matter becomes identified with non-being. Thus Aristotle says that Plato did not distinguish between matter as subject, i.e., as what receives a certain form, as the clay receives the shape of Socrates, and matter as deprived of some other form, like the shape of David.[8] For to be deprived of something is to have a kind of non-being.

Thus, Plato made non-being intrinsic to bodies through

[7] The particular difficulties raised by Plato are dealt with by St. Thomas in *De Ente et Essentia*, ch. 4.

[8] *Physics* I, 9, 192a2-6.

identifying it with space and space with matter, and the Atomists and Pythagoreans make non-being extrinsic to sensible reality. In both cases, we see an attempt to seize motion and difference through a simple dichotomy between being and non-being. While the dichotomy between being and non-being is obviously real, the lack of refinement in the notions of being and non-being leads, as we have seen, either to affirming the existence of non-being or to denying the existence of motion and difference. When Aristotle has finished his exposition of the principles of change, he is quick to point out that he has not subverted the principle that "what is, is and what is not, is not."[9] Accounting for motion and difference without doing this is perhaps his most important contribution to our understanding of nature.

Aristotle determines the principles of all change by looking at what his predecessors said as well as by looking at what is implicit in ordinary language about the world. He concludes to what may seem unimpressive, but is nevertheless of tremendous import: the principles of every change are the stuff which changes (the "matter"), that to which it changes (the "form" or "species"), and that from which it changes (the lack of the form to which it changes, the "privation").

But how can a lacking be a principle? How can it even exist? Is not Aristotle too saying that non-being is? No, not to be this is not the same as not to be simply. While it is true that being a triangle implies not being a square, to be a triangle is not to be not a square, i.e., being a triangle and being a square are two different but real things. It may even be true that we sometimes understand something only by negation of its opposite. When we say some bodies are animate, some inanimate, we are understand-

[9] *Physics* I, 8, 191b26.

ing the inanimate as what is not animate. There is some positive notion here, that of body, but the species inanimate body is known by negation. Still, there is a positive sort of thing there; the negative mode of knowing is more a failure on our part than of the part of the inanimate body.[10]

In the case of change of quality or quantity or place, there is a thing which remains throughout the change and which is the being that is at first deprived of the new attribute and later has it.[11]

The privation exists in the subject of the change and, though the privation is a non-being, it is in a being just because something else is not there. To be blind is to be not-seeing, and does not exist the way sight does; rather, the sight is a positive being which is present in the eyes, but not present in the eyes of the blind man. This does not imply that there is a subsistent non-being, only that there is an existent being, the eye, which does not have with it another being, sight. If I give you a dollar, I lack that dollar, but my lack of the dollar is not a real thing, it is only my being without the possession of the dollar.

Now, when I do not have an attribute but can have it, I am said to be "in potency" to it. This notion of potency, then, includes the notion of privation or lacking. Whatever is the matter of a change is therefore "in potency" to whatever is attained through the change, for what changes must lack the form but be able to have it. The matter, through the change, is formed or molded. The word "form" is used to denote the term of the change

[10] We might note that this is another case where the mode of knowing and the mode of being are not exactly the same.

[11] We need not worry now about the more difficult case of "substantial change," i.e., change from one kind of thing, like wood, to another, like ashes. We only need to speak of changes in which the matter is a thing, like a rock or a man.

and should be understood as such. The word has been extended from its meaning of "shape" given to some matter like clay, to whatever is given to matter by any change. It can even be extended further, as when St. Thomas says that angels are separated forms, but such further extensions lie beyond our scope here.

With this in mind, we can say that we should understand matter as what has the ability for form, and form as the term of a change. Since the change itself is defined in terms of the form, as when we define "healing" as the process towards health and "falling" as the process towards the place of the earth, we see that form has a sort of priority over matter and change—it is what defines them and perfects them.

We may draw from this analysis certain conclusions. Non-being need not be said to be simply in order to explain change, as the pre-Aristotelian philosophers thought, and the being which is changing, the matter, is to be distinguished from the non-being called privation. But matter does have an ordering to the possession of a perfection called form. The form may be in a way less good than whatever form is lost, as when a man dies, but the new form is still something which, though imperfect relative to the previous form, makes the matter more fully, is a perfection of the matter. Moreover, the matter may or may not have the form, so the matter is, in itself, an indeterminate principle. This is to say it is not fully determined in itself to one or the other forms it changes between. We will see how the Newtonian view of nature moves away from these insights in radical and unfortunate ways.

Having discussed the principles of all change, Aristotle goes on to discuss what nature, the subject of "natural philosophy," is: nature, he says, is a "principle of motion and rest in that in which it is, first, in virtue of itself and

not accidentally."[12]

He arrives at this by noting that natural things are opposed to artificial things—a bed may fall or burn, but only because it is made of wood, which falls or burns simply because it is wood. The wood does these things not accidentally, i.e., not in virtue of something else, but in virtue of what it is, in virtue of itself, while the bed does these things only because it is made of wood. Because it can do these things while other natural things, for example helium, cannot, there must be some principle peculiar to itself due to which it can do these things. That principle is the "nature" of the wood.

This is a first, most general conception of nature. Aristotle goes on to distinguish nature as matter and nature as form. Matter is a principle of motion in that it is what comes to be organized or formed in this way or that and so what can be moved to this or that new organization or form. Since matter is necessary for the change to occur, it is a principle of motion. Since it is in the wood as such, it is an intrinsic part of the wood. Consequently, it can be called "nature." On the other hand, nature is form, for it is form which determines how a thing acts, as man generates, not just any haphazard thing, but man.

The form we discussed above is akin to this form called "nature," but the word as used above was taken more broadly. As a principle of change, the form is whatever determines the matter and terminates the change. This may be a quality, a quantity, or a place. But, as we noted, a change may also terminate in a new kind of thing, a new substance, e.g., when wood burns and becomes ashes. If this is merely the result of the locomotions of very small particles, then there is no new thing there, unless we take "thing" loosely to mean "arrangement of things." But if

[12] *Physics* II, 1, 192b20-23.

we insist on explaining all substantial change this way, we are really denying the possibility of substantial change and confirming the reductionism of the materialists who would deny any significant difference between elephants and oak trees, the differences being, they say, only a difference of arrangement.

Now, the substantial change terminates in a new kind of thing, but even here there must be what underlies the change; if nothing does, we really have creation and annihilation, not natural change. This term of substantial change can also be called "form," by a further extension of the word. This form is what makes the underlying matter actual and makes the substance composed of matter and form be this or that sort of thing. It is this substantial form which Aristotle refers to when he says nature is form. He includes this sort of "form" when discussing the principles of all change, but excludes other sorts of "form" when identifying nature with form. The thing composed of matter and form, e.g. man, is not "nature" but "natural," i.e., principled in a certain way.

On this understanding of the natural world, there is, within each thing, considered not as to its accidental attributes but as such, the principle by which its motions become intelligible. For the form of a substance is what makes it be this or that kind of thing and explains the kinds of motions it has. Sparrows fly and rocks fall, whales swim but elephants lumber. I do not mean that we have some a priori notion of the nature from which we can deduce its motions, but that the motions which are in fact intelligible are in reality determined by some underlying principle, a principle we come to know only through that of which it is a principle, namely, through the motions and rests of the natural body. Take an analogy. When someone speaks to us, we do not know a priori what he will say from some intuition about his thoughts; rather, we come

to know his thoughts through his words. Nevertheless, it remains true that his words are as they are because his thoughts are what they are. If we know someone long enough, we can then say, with some certitude, what he will say in given situations, for we know his character. The case of nature is similar.

What this definition of nature means for the study of place is that natural bodies as such have a certain disposition or tendency to one or another place. In the Aristotelian cosmos, earth falls and fire rises naturally; in our own view, we might say that wood falls in air and rises in water, the direction depending on the environment. Something like this is true for Aristotle as well.

The word "motion" occurring in the definition of nature, Aristotle must go on to define motion. It is "the act of the potential as such."[13] What this means is hard to say, but this is only to be expected, because motion is one of those things which hardly exist, and which are consequently hard to define.[14] Without attempting a complete or exhaustive exposition, we can say that the definition does not say motion is mere act or mere potency: to be able to be somewhere and to be there already are neither one the same as going there. It seems that everything that is can be differentiated into what actually is and what potentially is, and that no more fundamental distinction is possible. If so, the notions of potency and act will be prior to the idea of motion and so able to be used in defining motion. Moreover, since what is in motion is precisely going from potency to actuality, it seems right to try to define motion in terms of potency and act. Thus, motion must be something in between potency and act—it is the act of the potential. Aristotle's own examples will suffice

[13] *Physics* III, 1, 201a10-11.
[14] *Physics* III, 2, 201b27-202a2.

as an explanation for now: the act of the buildable, as buildable, is that motion we call building, the act of the alterable as such is alteration, etc.

Both nature, insofar as it is a principle of determinate motions, and motion, insofar as it is the act of the potential, indicate a sort of determinateness of nature. For to say that this or that nature leads to this or that motion is to say that, in this regard at least, nature is not random, but ordered. And to define motion in terms of potency is to define it as something ordered by definition to some fulfillment. According to these definitions, the world is intrinsically ordered and intelligible, even if we sometimes have trouble seeing this order in particular cases.

Moreover, since nature is a principle of motion and a motion is by definition referred to some terminal act, nature tends to some determinate act. But is this act an "end" in the sense of a "best"? Aristotle, of course, says it is. He gives several arguments for this view. He says that the finality or purposefulness of nature is most manifest in the animals other than man. Spiders and ants work for some good, for their own preservation, and do so in such a remarkably intelligent way that some people wonder whether they might not be intelligent.[15] In looking at nature, it is undeniable that, if we are not prejudiced by some philosophical or scientific dogma, our first belief will be that these things act for the sake of some good. The prevalence of the Darwinian view of evolution prevents us from appreciating this fact. According to Darwin, animals "struggle for existence" and those best suited win and do, in fact, continue to exist. Yet even here we have to wonder why the individual itself struggles and to note that this struggling is for the sake of the good of continued existence. As Darwin notes, it is only by an extension of

[15] *Physics* II, 8, 199a20-30.

the word that we can say a plant in a desert "struggles" for existence. The more proper sense of the word seems to imply a good apprehended and sought in the face of obstacles, as when two dogs struggle for a bone or for dominance over the pack. If we drop this notion of the good from the idea of struggling, it seems we would have no real explanation of the natural order at all. We see animals struggling and we ask why. Darwin seems to want to say, "not because of some goal; they are just struggling." This is repeating oneself, not explaining things. In any case, the direct observation of nature, undertaken without any presuppositions, would lead us to say that animals and plants act for the sake of a good. Aristotle seems to take the finality of nature to be better known than the premises of the possible objections to it.

Aristotle also argues that the analogy between art and nature leads to the same conclusion. We can see that the steps in a process of making are ordered to some good. We first lay the foundation of a house, then put up the walls and then a roof. These steps are determined and made intelligible by the fact that the house is for the sake of shelter. If we want to build a car, we do not lay a foundation first, because the end is different. In nature we see a similar ordering of steps. The wasp first digs a burrow, then goes off to paralyze a grasshopper, then lays its egg on the fresh, living belly of the victim, puts it into the burrow and covers it up.[16] This order or some other determinate order is always followed by each species, so that it cannot be an accident that the order is followed. But insofar as the steps in the natural process and the steps in the artificial process are alike, they must have the same sort of principle governing them. We know this principle

[16] Cf. J. Henri Fabre, "The Wisdom of Instinct" in *The Insect World of J. Henri Fabre* (New York: Dodd, Mead, and Company, 1949), pp. 42-54.

is the purpose in the case of artistic processes, so there must be a purpose in natural processes as well.[17]

But what of the sort of absolute necessity advocated by some modern authors? Why should we not say that the physical world is determined solely by prior causes, i.e., material and agent causes? This is the view of Empedocles and the Atomists.

Besides the arguments already given, Aristotle also presents the following argument: Things happen either by chance or for an end. What happens by chance happens infrequently, so what happens always or for the most part happens for some purpose. Nature acts always or for the most part, therefore nature acts for an end.[18]

The assumption in this argument is that chance is an accidental cause, i.e., a cause which is only incidentally related to its effect. A doctor, e.g., may build a house. Here, the art of medicine is accidentally joined to the housebuilder, and so we have an "accidental" cause. When an event occurs by chance, something like this happens, but what is accidental is joined to the effect, not to the cause. For example, if I dig a fence post hole and find a golden spoon, that's luck. The finding of the spoon is accidentally joined to my effect, the hole. These are both cases of accidental causality, but are not accidental in just the same way. Since what merely happens to be joined to an effect, i.e., is "accidentally" joined to an effect, will not usually be joined to it, chance events are rare.

But Empedocles and the Atomists hold that the world is a result of absolute necessity, but also, in a way, of chance, since they imagine their necessary causes to work to no end. Rather, they hold that the constellation of necessary causes brings about an unintended good, e.g., that our

[17] *Physics* II, 8, 199a8-20.

[18] *Physics* II, 8,198b34-199a8.

teeth are well-suited to eating. This good, they say, is accidental to the causality of the agent, since it is outside the intention of the agent (in fact, the agent has no intention at all), but the effect comes about always or for the most part because the agent always acts in the same way. Somehow, they think, the goods we see in nature are mere by-products of mechanical necessity.

It is clear that "chance" would mean here something different from what Aristotle and common usage take it to mean. For the common sense view is that chance can occur only when there is an agent acting for an end, and even then not every accidental effect is called chance. If I go to a store and meet my long-lost brother, I am lucky; but it is equally accidental that I meet the fellow who lives at 3490 Oak Avenue, Apt. 3B, whoever he is. But we do not say that all such random encounters occur "by chance" or are "lucky," because I am indifferent to them. Only if the result makes a difference to me do we call it lucky or unlucky. But if agents never act for ends, every result is indifferent, and there is no such thing as luck or chance in the normal sense of the word.

We might put the question more positively thus: is it true, as Aristotle assumes, that every cause which is determined to its effect is acting for that effect as for an end? An objection immediately comes to mind: the nature of a mathematical object is the cause of the perfectly determinate properties it has, but the nature is not ordered to these properties as to an end. We can extend this even to natural things: the property of man, that he is risible, follows from his nature with absolute necessity and is not the final cause of his nature.

In response, we should first note that the counterinstances are taken from formal causality, whereas everyone agrees that chance, if it exists, is among agent causes. What belongs to a form, whether as a part of its definition

or as a property following from it, is present whenever the form is, but what follows upon the agent is not always present when the agent is. The house-builder may become a doctor and never build a house. Our question is really whether every agent cause which is determined to an effect is acting for an end. But because we are concerned with causes in nature, not with immaterial causes, we may restrict our question further by asking only about natural agents. Perhaps the following argument shows that a natural agent, determined to an effect, is acting for that effect as for an end.

The processes of nature are not the results of accidental causes, for they are always or for the most part the way they are, while accidental causes could only occasionally produce the same result. The causes of natural processes are therefore per se causes. But natural processes are finite processes, as we see by experience. There are a great number of steps in the production of an adult from an egg, but the number is nonetheless finite. Thus there is some end to the process, "end" here meaning "temporally last thing." But what can account for the process ending here and not at some other stage? If the cause of the process is simply efficient, then it would seem the only restriction on the work of the cause is its own capacity. Supposing this is finite, it would have to stop acting at some time. But we see that there is a limit set on the working of efficient causes in nature, a limit which is reached before the cause is exhausted. Lions do not keep running after catching up with an antelope. We see this limitation in cases when the parts of organisms grow out of proportion to the organism as a whole or, more positively, when plants and animals stop developing in certain ways without any apparent change in the abilities of the organism to continue developing in those ways. Consequently, it cannot be a mere impotence on the part of the cause that limits its activities.

If we say that what is limiting the power of this cause is some second efficient cause, we would have to ask why this limiting cause does not simply prevent the working of the first cause; in other words, what limits its activity? The efficient cause in and of itself could only explain the finitude of its effect if it were intrinsically limited by its own impotence. When the efficient cause is not limited in this way, it seems that the only plausible explanation of the limitation of the efficient cause is that there is a final cause toward which these efficient causes are working. Thus, the view that natural processes are a result of non-accidental but nevertheless purposeless causes seems to be untenable.

If motion and nature are as Aristotle says they are, when a body changes place it is attaining some new actuality, in respect to place, and, if the motion is a natural one, this new place is somehow better for it. It is not necessary to say just how this or that place is better for this or that body: nature loves to hide. In modern terms, one would have to know the properties of the many elements and of their interactions to answer this. But in general, our experience of the world seems to lead us to the view just laid out. However these general principles are incarnate in particular bodies, they are in any case incarnate somehow. This way of talking in general terms but not in particular terms is one thing that some renaissance thinkers seemed to hate about Aristotle—Francis Bacon comes to mind—but according to Aristotle, it is the only way we can begin physical science. The mind seems first and most certainly to hit upon general considerations like the fact that there is motion before hitting upon more particular considerations like that of the equation for the fall of heavy bodies. Doubtless the latter is more useful, as Bacon and Aristotle both insist, but the former is prior in our knowledge and

is the basis of any certain knowledge we can have.[19] In the present context, we see that natures have principles which are ends, final causes, because of our general discussion of what nature and motion are, though we are hard pressed to give a detailed explanation of particular locomotions in terms of finality.

If we deny this, we are forced to say there is no intrinsic reason for the order of the universe. We are tempted to say that the present order is just a consequence of a previous order, but, unless we bring in the notion of a natural place, the previous order is just as arbitrary, and so we have not really advanced one step. Not advancing one step again (by reducing our new order to another, even earlier order) will obviously not help. In short, we have to go to something of a different kind if we are finally going to explain anything of a certain kind; here, we have to go beyond arrangement to explain arrangement.

So when a body moves and attains a new place, there is first of all something happening, there is some difference between the prior and the later situations, and secondly, if the motion is natural, there is a better situation at the end than at the beginning.

Let us concentrate on the first of these facts, that when a body changes place there some newness involved. What is this newness? Is it a newness which lies in the body or in the place? Certainly, insofar as the place was previously occupied by some other body, the place has something new about it. But this does not seem to be a difference for the place as such, for we say that the mobile is in the same place as another body was in previously. In other words, when a body moves it is the body itself which is affected, not the place, except perhaps accidentally. Consequently, as nothing has changed but the place of the

[19] *Physics* I, 1, 184a10-b14.

mobile, there must of necessity be a difference between one place and another. Hence Aristotle's numerous arguments against void space, which would be undifferentiated because non-being is undifferentiated, and so unable to deliver the newness necessary for local motion.

This leads us to ask, finally, what place is. Aristotle says that place is the surface of the surrounding body. He arrives at the conclusion that this surface of the surrounding body is place by finding four possible genera of place (form, matter, an independent dimension, and the surface of the surrounding body) and rejecting three of them. The dimensions which we imagine underlying bodies would have some of the characteristics required of place: immobility and equality with the placed. On the other hand, when we ask where something is, we name some body, like a room or a box. And, in Aristotle's example, you are in the heavens because you are in the air which is in the heavens, and you are in the air because you are in this part of the air. The most proper answer to "where are you?" seems to be in this surface of the air which is contiguous with you. It is due to being in this surface that you can be said to be in the air as a whole and then in the heavens. Moreover, it is easy to see what "in" means in this case, but in the case of space it is harder—space seems to "coincide" with body rather than to "contain" it.

Aristotle concludes that place is the innermost surface of the surrounding body. But how can the surface of a mobile body be immobile? Aristotle seems to say that the surface of a body is mobile not insofar as it is place but insofar as it is an accident of a body. As place, it is immobile in that it has a certain determinate order to the whole heavens. Thus, we speak of the "same" river even as it flows by. When water flows past a moored ship, the water is continually other, but the surface of the water in contact with the ship has always the same relation to the whole

heavens.[20] Considered thus, place is immobile. Aristotle's final definition, then, is "the first immobile surface of the surrounding body."[21]

The body can move in place due to its materiality with respect to place, i.e., because it is a subject different from place but having dimensions able to be enclosed by, but not necessarily enclosed by, the surface of a certain environing body. A body can therefore come to have a predicate denoting placement. This predication is an indication of some reality, that of being in place. For Aristotle, the potency of a body for this sort of reality is the root of local motion and of placement. The body is not, in a qualified sense, but absolutely speaking, it is: It is not in place B, but it is a body of such and such a kind, weight, colour, etc. So the body, before moving, is a subject with a privation, the privation of being in place B. It actually has some other place, call it place A. Then it moves. When the body reaches place B, then the potential of the body to be in place B is actualized. But the act of the potential to be in place B, when the potential to be there, and so the privation of place B, is still in it, is the motion to place B. This explanation does not involve the existence of a pure non-being, nor does it make of place a sort of matter, as Plato claimed space was, but only insists that the placed be material in regard to placement.

We can better understand why Aristotle argued against the void in this light. Finally, positing the void to account for motion is related to, if not the same as, claiming that non-being is necessary for motion. As we saw, this was the view of Parmenides and the Atomists.

[20] Cp. Meteorology II, 3, 357b27-32.

[21] *Physics* IV, 4, 212a20-21. Aristotle's discussion of place comes in *Physics* IV, 1-5; the argument to the definition of place comes in IV, 4, 210b32-212a21.

We can see Aristotle's argument from a hypothesized speed in the void in the light of the uniformity, or better, non-formedness, of the void. He says that one reason bodies fall at different speeds is that there are differences in the media through which the bodies are travelling. He claims that the difference in the viscosities of the media is directly proportional to the differences in the speeds. Since a void has no power to resist at all, bodies would fall instantaneously in it.

This argument has been much despised, the main line of attack being founded on the view that bodies have natural velocities from which the medium takes away—that is, the law should not be that velocities are proportional to the media, but that the velocity is some natural speed minus the resistance due to the medium (symbolically: not $v1:v2::m1:m2$, but $v=k-r$). Looking at Aristotle's argument from a more universal point of view may help us to see more in it than a simple misformulation. For we could say that in the absence of material media, the mobile need actualize no potency in going from A to B, so that there is no work to be done in moving something. Consequently, any motion in a void would take place instantaneously. On this reading, the argument presumes that void is just non-being. If we say it is dimensional or dimensions, the presence of the parts of the dimensions permits a sort of otherness, and perhaps this would be sufficient to account for a hypothesized finite speed through a void.[22]

There is also an interesting argument which assumes void is dimensional. Is it the matter of the body which does this? No, for matter is only potentially this or that and so cannot give to a body whatever is necessary for it

[22] Cp. St. Thomas' criticism of this argument. *In Octo Libros Physicorum Aristotelis Expositio*, ed. P. M. Magiòlo, O.P. (Rome: Marietti, 1965), L. IV, l. 12, nn. 534-536.

to be in place. Nor can it be the colour or any of the other qualities which make it be in place, for these all seem to be in place insofar as they inhere in the dimensions of body, as colour is in the surface, for example. But if the body somehow lost its dimensions, not these or those dimensions but dimensionality itself, it would no longer be in place, so that the body is in place through its dimensions. That the size of the place of a body is determined by the dimensions of the body and that a body changes place by traversing dimensions or through its size changing are facts which point in the same direction.

But a peculiarity of dimensions is that they are distinguished only by position. If two lines are on top of each other, there is really only one line, though we may consider it as two, as in the fourth proposition of Book I of the Elements. This is what led the Pythagoreans to say that the unit-numbers are separated by a sort of dimensional nothingness, for points, like lines and surfaces, are only different by position. If the void is dimensional, then, the quantity of a body in it will be indistinguishable from the void itself. But then why posit the void?

We might object that when two bodies are in contact, their surfaces are together but not one. But this is only understandable because the surfaces have sides: the surface of body A is the surface of a body on this side, the surface of body B is the surface of a body on that side. With the void, this distinction is impossible, for we would have to say the void and the body had another side besides their three obvious dimensions, and that the void and the body did not coincide in this fourth dimension. This seems an odd assumption; moreover, place would not equal the placed.

In the light of our review of Aristotle's position, we can see how he avoids the pitfalls into which his predecessors fell. He need not say the void exists, that non-being is, to

explain motion, for he can explain motion by the potency of matter to different forms. We still might think we have to posit a void to account for motion on the grounds that a body cannot move into a place already occupied. In discussing rarefaction, Aristotle points out that if we make a large circle smaller, we do not introduce curvedness where there was none before, but rather, we curve more what was curved less.[23]

There is no need, in other words, to posit a non-being to explain motion; the potency of matter is sufficient for this. The ability of matter to rarify and condense, which does not imply the existence of vacua within the body, allows a body to move forward without there being an actually empty space before it. So the only sort of non-being needed for local motion is privation, which is only a qualified non-being, a not being this, or in this case, a not being there. In finishing his discussion of void and place with a discussion of how the general principles of change outlined in Book I of the Physics can explain rarefaction and condensation without assuming a vacuum, Aristotle is perhaps underlining the role of potency in any sane physics.

II
Newton's View and Its Historical Background

The next important author after Aristotle, for our purposes, is John Philoponus, who lived around the sixth century and wrote commentaries on several of Aristotle's works. Philoponus is the first to formulate the objections to Aristotle which later became commonplace: the law of fall need not be proportional, it can be subtractive, i.e., it might be expressed as v=k-r rather than as v1:v2::m1:m2.

[23] *Physics* IV, 9, 217a26-b11.

As to the problem of projectile motion, Philoponus says the thrower gives to the mobile a "certain incorporeal motive act." In the void, the projectile would move even faster, not being retarded by the air, but not instantaneously, as Aristotle would have it, because the mere traversal of distance takes time.

Through the Arabs, especially Averroes and Avempace, the Latin scholastics were influenced by Philoponus. These scholastics usually accepted Arisototle's teachings but often held that those arguments criticized by Philoponus were *ad hominem* arguments in the first place. This claim seems true most notably in the case of the argument that bodies would fall with an infinite velocity in the void because the void cannot resist. For in the *De Caelo* Aristotle presents an argument which assumes that all of the resistance to motion is from the mobile.[24] Thus either the argument in the *De Caelo* or the argument in the *Physics* is *ad hominem*, or they both are. The *Physics* argument at least would seem to be, for we can offer a counter-example from Aristotle's own cosmology—the heavenly spheres are impeded by nothing and yet travel with a finite speed.

As to the argument over projectiles, the Latins followed the Arabs in treating it in two ways. Thirteenth century authors often claimed that the thrower gave to the mobile an "impressed force" or "impetus" which died away of itself, leaving the body at rest. Fourteenth century and later authors often presented the same basic view but with the qualification that the impetus was permanent. These views clearly have an affinity with the "inertial" theory of motion, but it should be remembered that the inertial theory is really claiming that uniform rectilinear motion needs no cause while impetus theories are attempts to find its cause.

[24] *De Caelo*, III, 2, 301b2-17.

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As might be expected, theological considerations played no mean role in forming medieval concepts of space. The most significant single event having to do with this in medieval times was the condemnation of certain propositions in 1277 by the Bishop of Paris. Among the views condemned were these: that God could not create a plurality of worlds and that God could not move the world in a straight line because a void would be left behind.[25] It was also thought impossible that a pre-creation void, independent of God, was necessary for God to have created the world from nothing. This was a view Averroes had expressed. The first two condemnations led to the view that there is empty space beyond the outer sphere. This was usually called "imaginary space," though this expression was interpreted in radically different senses. For some, "imaginary" meant real but apprehended by the imagination, for others, "existing only in the imagination," i.e., not really existent, for others, "existing only accidentally," and so on.[26] The idea that a pre-creation void is necessary also led to much debate. If the world is not eternal then there must have been a place to put it into. This place could not be independent of God, for then there would be two eternal and necessary beings. Consequently, space must be an aspect of God—his "immensity." For some, this led to saying space is non-dimensional, for others, to saying that God is dimensional. Nicole Oresme argued that if God is not a dimensional space, there is no way to understand how He could move the world in a straight line. For there is no body outside the universe in relation to which such motion could be judged. Samuel Clarke, expressing New-

[25] Heinrich Denifle and Emil Chatelain, *Chartularium Universitatis Paririensis*, 4 vols. (Paris: Fratrum Delalain, 1889-97), vol. 1, pp. 545-546, Articles 34 and 49.

[26] Cf. Edward Grant, *Much Ado About Nothing* (New York: Cambridge University Press, 1981), pp. 117-121.

ton's views in his correspondence with Leibniz, argued for absolute space in the same way. Other similar problems were raised: since God is infinite, and the world finite, there must be space outside the world; since God can create a world separated from this one, He must be able to be someplace else, for there is no action at a distance—and since God is immutable, He must already be in that other place.

In one way or another, these arguments found their way into Otto von Guericke's famous treatise on void, *Nova Experimenta de Vacuo*. He opted for the view that God is space. Henry More, a "Cambridge Platonist" and a friend of Isaac Newton, went further still. In opposition to Descartes' notion of an extensionless *res cogitans*, More believed that all things were dimensional. If spirit is dimensionless, he argued, how can we account for the interaction between mind and matter? And as God is omnipresent, He must be dimensional. Again, by noting that God and space have twenty attributes in common, More claimed to show that God and space were, in fact, the same thing.[27] These views are apparently derived from a Hermetic text, *Asclepius*, which was popular in medieval and renaissance Europe.

Besides this theological strain, the other historical trend leading to Newton's absolute space was the growing tendency to treat nature mathematically. Galileo's work is characterized by this tendency. He uses Philoponus' argument, which he seems to have picked up from read-

[27] Those which More lists are: one, simple, immobile, eternal, complete, independent, existing in itself, subsisting by itself, incorruptible, necessary, immense, uncreated, uncircumscribed, incomprehensible, omnipresent, incorporeal, all-penetrating, all-embracing, being by its essence, actual being, pure act. For a discussion of More's views, cf. Alexandre Koyré, *From the Closed World to the Infinite Universe*, (Baltimore: The Johns Hopkins University Press, 1957), pp. 110-154.

ing the medievals, against Aristotle's law of fall to justify belief in the void. Moreover, Galileo's general method leads perhaps not inevitably, but fairly determinately to the idea of place as three-dimensional void space. The void is a "background" for motion, a steady frame of reference against which motion may be measured. It is the limiting case for motion, an idealization which permits mathematical treatment. In the homogeneous void inertia becomes possible, for when there are no differences between places there is no reason to stop here rather than there. In short, if place is homogeneous, locomotion can no more tend to one place than to another. With inertia, the mathematical treatment of motion is greatly facilitated, for accelerated motion is always understood through uniform motion, and the theory of inertia allows us to take this intellectual necessity as being a simple mirror of nature.[28] It is by the addition of complicating factors to the simplicity of the ideal case that Galileo hopes to describe the motions we see actually occurring around us. "All of Galilean science rests on the substitution of a more simple ideal world for the too-complex real world."[29]

Newton too argues that God is ubiquitous and immutable, so space must exist prior to finite and mutable bodies. If space is not an aspect of God, then either God created his own ubiquity or He created our space though He remains outside of it. Both consequences are

[28] This is not to deny that uniform motion is in some sense naturally prior to accelerated motion; it is to deny that the motion which is in some way naturally prior and which must be understood to understand the posterior motion must actually be the "normal" or unforced motion of bodies. This confusion is perhaps another example of assuming that the mode of being and the mode of knowing are the same.

[29] Maurice Clavelin, *Philosophie Naturelle de Galilée, Essai sur les origines et la formation de la méchanique*, (Paris: Librairie Armand Colin, 1968), pp. 379-380.

unacceptable—hence, space is an aspect of God. Space is, Newton says, "as it were," the sensory of God.[30] Newton also argued for a space independent of bodies by resorting to the medieval claim that God could annihilate any body, leaving a void behind.[31] Moreover, if God cannot make a void, He is not omnipotent.[32] Newton also argues, in opposition to Descartes, that space is not matter. For space is infinite. If space is matter, then matter is infinite. If so, it is eternal and necessary. The assumption seems to be that whatever is infinite is eternal and necessary, though why this should be so is unclear. Perhaps Newton concludes this from the association in God of infinity, eternity and necessity. In any case, that matter is eternal and necessary is contrary to faith.[33] This argument also underlines Newton's belief that space is eternal and necessary, for he clearly thinks space is infinite. He gives three reasons for this. First, we have to imagine it so.[34] Again, God is infinite, so the space He is in is infinite.[35] Finally, only an infinite space could be immobile, for it seems a finite space could be moved in a straight line.[36]

Newton also gives non-theological arguments to support the view that place is an independent space. First, we

[30] Newton, *Opticks* (New York: Dover, 1952), L. III, Query 28, p. 370; *De gravitatione*, in *Unpublished Scientific Papers of Isaac Newton*, eds. A. Rupert Hall and Marie Boas Hall (New York: Cambridge University Press, 1978), p. 102 and 104.

[31] *De gravitatione*, p. 99.

[32] Ibid.

[33] Samuel Clarke, Quatrième réponse de Clarke in *Correspondence Leibniz-Clarke*, ed. Andre Rabbinate (Paris: Presses Universitaire de France, 1957), pp. 111-112, 113.

[34] *De gravitatione*, loc. cit; cp. Physics III, 4, 203b22-30.

[35] *De gravitatione*, p. 102.

[36] Mathematical Principles of Natural Philosophy, Motte trans., revised by Florian Cajori (Los Angeles, CA: University of California Press, 1962), Bk. I, Scholium to the Definitions, p. 9.

cannot not imagine space, though we can imagine any or all bodies not to exist, so space must exist independently of bodies.[37] Secondly, the place of a whole is just the sum of the places of its parts.[38] This implies that space underlies bodies in all three dimensions and so can coexist with bodies. If so, it would seem to be something apart from that body and any other.

The existence of an actually void space, as opposed to one which is independent of body but is occupied, is established, according to Newton, by Boyle's experiments with artificial vacua,[39] by the fact that bodies can rarify[40] and by the apparently frictionless area outside the earth's atmosphere. This area seems to be frictionless because the planets and comets never cease their rotation around the foci of their orbits.[41]

We see here Newton's dependence on theological speculation to establish the existence of independent space and to explicate its nature. We also see that, although none of the arguments are simply mathematical, the notion they lead to is that of an objectified mathematical background for motion.

III
The Significance of These Differences

One result of all this has frequently been noted. The acceptance of the theory of inertia is finally linked to the

[37] *De gravitatione*, p. 99.

[38] *Principles*, Bk. I, Scholium to the Definitions, p. 7.

[39] *Principles*, Bk. III, General Scholium, p. 543.

[40] *Principles*, Bk. III, Proposition VI, Theorem VI, Cors. III, IV, p. 414.

[41] *Opticks*, L. III., Query 28, p. 368. This Query, the *de Gravitatione*, and the *Mathematical Principles*, Bk. I, Scholium to the Definitions, pp. 6-12, and Bk. III, General Scholium, pp. 543-547, are the central Newtonian texts on space.

view that place is an independent space. If there is no difference between places, then a body has no intrinsic reason to stop anywhere. It will keep going until something stops it. While a body might need a "force" to get it going, it needs none to keep going. Consequently, motion and rest are on the same ontological level and we have the odd notion that motion and rest are both "states"—the word "state" coming from the Latin word "status," "way of standing." Motion and rest are the one as actual as the other. The fact that bodies would still come into different relations with each other does not seem to require any potency, for it makes no difference which bodies are moving and which are at rest when they are so rearranged. The "moving," then, does not introduce anything new to the body. But one might think that there are new relations to absolute space when a body moves. While Newton clearly holds that this is so, it is equally clear that this new relation makes no difference to the body or to space. There is at most a sort of indifferent potency, an indifference which makes all motions the result of extrinsic movers, of violence, of "force" in Newton's terminology. Making place an independent space, then, rids motion of its potential aspect to a great extent at least, and thus changes our conception of movement.

Further, there is no more finality in local motion, for all places are the same. Nothing acts to obtain what it already has, or to obtain something identical to what it already has, unless it is not acting for an end but is simply acting. Thus, any finality in nature must be derived immediately from an extrinsic source. This "clockwork" universe is not compatible with Aristotle's claim that things have natures, and these natures are principles of certain motions rather than others. On Newton's view, what happens to a body must result only from what other bodies happen to do to it, or what God does to it. The analogy to the mechanical

clock is apt: the parts of a watch do not act out of their intrinsic inclinations, but are pushed and pulled by each other according to the plan of the watchmaker. The purposefulness of this pushing and pulling is derived immediately from the maker, not at all from the steel and copper. If everything is like this, then, as the mechanist says, the parts of the universe, carbon and hydrogen, etc., and the parts built up like watches from these, water, DNA, cows, and men, have no intrinsic ordering to an end, but are perfect or not only insofar as they conform to an end arbitrarily assigned by God, so there really is no intrinsic perfection of natural things. In this regard, God stands to the world as a farmer to his chickens. The farmer does not care about any goods which are good for the chickens themselves, he is concerned with what is good for himself, and the chickens and their goods are good in his eyes only insofar as they promote his good. Here, though, we have two goods, which sometimes agree and sometimes disagree; if the mechanist is right, the good of the chicken is just an illusion.

Aristotle defined nature as a principle of motion and rest. Now that Newton has rid himself of motion as we know it and Aristotle defined it, the definition of nature must also be rejected. In fact, there is no longer any nature in the sense of an intrinsic principle of moving in the mobile; instead, motion is a state which itself changes only when a force acts. The notion of violence which is found in the root sense of the word "force" is fitting in the light of this. One might think that the passive sense of nature, due to which Aristotle says that nature is matter, might still find a place in a Newtonian scheme because there is still the possibility of being accelerated by an extrinsic force. But this too will be mitigated or done away with entirely, again because there is finally no new sort of act attained by a body in changing place, whether through

uniform or accelerated motion.

Not only does the Newtonian view do away with potency in the mobile, it also does away with the potency of place itself. For Aristotle, there is potency in place insofar as any place is the surface of a surrounding body. When a body moves through air, then the air is divided in other and other parts of itself, and so is going from potency to act. This potency does not, however, involve the movement of place as such but only of the matter of place, i.e., the surrounding body and its surface not considered as having a determinate relation to the heaven. It might, then, be better to speak of the potency of the matter of place. But in Newton's absolute space a body's passage has no effect at all; space is impassible, independent, and formal; it is, in fact, divine, pure act.[42]

This view, then, is at the opposite extreme from that of Plato and the Atomists, though, like these earlier views, it too tends to suppose a simple dichotomy between being and non-being and to overlook the centrality of passive potency in the natural world. We saw that the earlier thinkers assumed the real existence of non-being in order to account for motion and difference. While Newton is not as articulate about his more general views as one would like, we can say with some certitude that he has made absolute space a condition of motion, and in some sense identified that space with God. In short, he has made the non-being of the Atomists into the first being, as Aristotle predicted would happen to those who make place independent of body:

> . . . if place is such, the power of place would be something

[42] Newton does speak of space as a "disposition of being as being" and as an "emanent effect" of God. (*De Gravitatione*, pp. 103, 104). Space seems not to be the essence of God, but perhaps a property flowing from his essence.

> wonderful and prior to all things. For that without which not one of the others is, but it is without the others, is necessarily first; for place does not perish when the things in it are destroyed.[43]

Thus, oddly enough, where the Atomists put non-being outside and Plato inside bodies, but only as one aspect, the matter, of bodies, Newton puts being outside bodies and makes what seems to be more real, bodies, less real, more non-being that what appears to be non-being. But bodies are also in a way elevated beyond non-being. Visible bodies are thought to be composed of invisible atoms, and the latter bodies are identified with their quantity.[44]

But quantity is not, as such, something in potency, but a certain determination of body, something formal. It serves as subject for qualities such as colour, taste, smell, etc., but all these are reduced by the mechanist and Atomist to mere illusions, "secondary qualities," as John Locke called them.[45] Thus, what is real in bodies is only quantity and aspects of quantity, such as shape. In one work, Newton goes so far as to speculate that body is nothing but space endowed with impenetrability and mobility.[46] Given his views on the divine nature of space, expressed in the same work and implied elsewhere, we must conclude that Newton thinks of bodies as real to a degree that shocks common sense.

Where Aristotle had found within bodies an imperfection which at once accounts for the non-being implicit in motion and difference and for the direction of mobiles to more perfect states, Newton sees only a swirl of atomic bodies, each independent and complete and so seeking

[43] *Physics*, IV, 1, 208b33-209a2.

[44] Cf. *Principles*, Bk. I, Definition I, p. 1.

[45] *Essay Concerning Human Understanding*, (New York: Dover, 1959), vol. 1, pp. 169-173.

[46] *De Gravitatione*, pp. 105-106.

nothing beyond itself. By raising body and place beyond both non-being and potential being, Newton removes the source of both order and of indetermination in the world. In this way, Newton's views are a step back even from Plato's, for Plato at least saw that there must be a principle within bodies to account for their indetermination and ordination to being. But where Plato had made non-being too real, Newton makes it too unreal, in that he does away with potency and privation (except, perhaps, in some very attenuated sense). Stated in such bald and abstract terms, Newton's error seems the more reasonable (and it is natural in a sense), but in terms of our concrete experience of the world of change, Plato's view is perhaps the more plausible. For our daily experience is just that, daily, and implies the irrevocable loss of everything we see and touch. Through memory and expectation we make the flux of the world an almost stable being, but, distinguishing again between what belongs to the object of knowledge in itself and what belongs to it due to our mode of knowing, we see that the grasp on being which we and the natural world have is astonishingly weak. Newton's views seem to reject this insight, to reject also Aristotle's natural solution to the apparently insoluble paradox of motion, to accept a rationalistic dream of the perfect intelligibility of nature.

The differences between Aristotle and Newton arise from different views of proper procedure in physics. While Aristotle approaches the problem of what place is through a consideration of motion and natural beings, Newton's view is largely reached through theological and mathematical considerations, and so through considerations which are finally extrinsic to the subject matter he is concerned with. As we saw, though, he does not exclude properly physical considerations.

Let us look for a moment at these two approaches to physics and their implications. Galileo makes the follow-

ing claim in the *Assayer*:

> Philosophy is written in this grand book, the universe, which stands continually open to our gaze. But the book cannot be understood unless one first learns to comprehend the language and read the letters in which it is composed. It is written in the language of mathematics, and its characters are triangles, circles, and other geometric figures without which it is humanly impossible to understand a single word of it; without these, one wanders about in a dark labyrinth.[47]

If we wish to do physics mathematically, we have first to make of the world a mathematical being. This we can do either because it is mathematical through and through, as Galileo claims here, or because it has a mathematical aspect, as Aristotle claims in the *Physics*.[48] Suppose that we believe we can obtain knowledge of the physical world through mathematics. Does it not follow that the world itself is mathematical? For we would, generally, say that to have knowledge of a thing is to see it through its own principles. But then how can Aristotle say that there is a science of physics which proceeds mathematically, as does optics? Optics treats mathematical lines as physical, he says, while geometry treats physical lines as mathematical. In other words, when we study geometry, we are studying things that exist in the physical world, lines and angles for example, but are not considering them as they exist in the physical world. Rather, we are treating them as they exist abstractly. We "abstract" from the matter which is curved or straight and consider only the shape itself. When we do this, we find the object of our thought in our imagination. In optics, we reverse this order, tak-

[47] Cf. Galileo, *The Assayer*, trans. by Stillman Drake in *Discoveries and Opinions of Galileo*, (Garden City, New York, Doubleday, 1957), pp. 237-238.

[48] *Physics* II, 2, 193b22-194a12.

ing these abstract geometrical lines and treating them as physical, i.e., as they exist in the physical world. In mathematics, we treat the formal aspect of things, in physics, both the formal and the material. When doing a "mixed" science, like optics, we consider purely mathematical and formal objects and then see if the result of our work has any relation to the physical world. This is done through experiments or observations involving measurement.

One might ask why one would need to verify experimentally what has been mathematically deduced from observations. If the observations have been correctly formulated, i.e., if the equation describing the phenomena is correct, and the mathematical analysis has been correctly carried out, it seems the conclusions too must be as certain as the formulation of the original observations, especially as mathematical objects are originally derived from experience. If we say that formulation is itself dubious, because of the inaccuracies of all measurement, and that it follows that we need to verify our formulations through our observations of those phenomena supposedly implied by the original formulation, it remains that this new observation, which must involve the same sorts of fallible measurement, will itself be as dubious as the original formulation. This would result in the prevalent view of scientists that our physical science is an endless approximation of reality.

For Aristotle, the difficulty lies deeper. One needs to verify the mathematically implied result because the world is not finally mathematical. What is implied by the mathematical formulation, even though this formulation is derived from the physical world, does not necessarily apply to the physical world because what is true in the abstract need not be true in the concrete.[49] For example, if 50 men

[49] *De Caelo* III, 1, 299a11-16

move a ship 50 feet in an hour, it does not follow that one man will move it one foot in an hour, for he may not move it at all.[50] Consequently, if a certain formula implies a certain result, we need to check this result in the physical world, and not only because the original formula is dubious to the extent that it relies on imperfect measurements, though I see no reason for Aristotle to deny that this too is a factor. One example of carrying faith in mathematical formulations too far is Philoponus' argument that because the law of fall may be v=k-r (let us suppose it is), a body can in fact fall in a void. This formula may be true when applied to bodies falling through media but it does not follow from that fact that a body will fall through a void at all. An independent experiment would be necessary to verify this.

To see more clearly how this principle, that what is true in the abstract need not be true in the concrete, applies to the question at hand, we have to distinguish between the sort of abstraction involved in physics and the sort involved in mathematics. The example Aristotle uses is of snub-nosed and curved. If we think of what a snub-nose is, not of this or that particular snub-nose but of snub-nosedness itself, we still have to include in our consideration sensible matter. We still have to speak of a nose, something made of flesh and bone. But if we consider what we call the form of the snub-nose, the curved, we need not mention flesh and bone. In the first case, we abstract the universal from the particular, in the second, we abstract the form from the matter.[51] What is true of the abstract universal is also true of the concrete particular,

[50] *Physics* VII, 5, 250a12-19.

[51] Cf. St. Thomas Aquinas, *Expositio super librum Boethii De Trinitate*, Q. 5, Arts. 1-3; and *Expositio in duodecim libros metaphysicorum Aristotelis*, L. VI, l. 1.

so that what is true of snub-nosedness or man is also true of this snub-nose or this man. But what is true of form considered in abstraction from matter need not be true of form in matter, for the composite of form and matter has an additional element, the matter, which may cause certain of the implications which form has to be denied realization. For example, if we calculate the velocity of a body which is thrown vertically upwards, we find by calculus that it undergoes continuous motion starting from the hand, rising to a determinate height, and then falling back. But it may be that there must be rest at the top of the path, a fact which would be revealed only by a physical investigation, perhaps of the sort Aristotle presents in the *Physics*.[52] On any view, then, experimentation becomes an essential part of science when we wish to proceed mathematically.

Newton is, as always, more cautious than Galileo. But while the title of his most famous work, the *Mathematical Principles of Natural Philosophy*, might leads us to believe that he holds there are also non-mathematical principles of natural philosophy, it is still clear that, however he may view the exact relation between the mathematical and the non-mathematical principles, he believes that the implications of the mathematical principles will necessarily hold in the physical world. In his preface to the first edition of the *Principia*, Newton goes so far as to say that geometry is a part of universal mechanics, a part which deals with what can be determined with perfect accuracy. This universal mechanics seems to be the knowledge of the workings of the world as a whole. The perfect mechanic, who is, I suppose, God, sees the world as a mathematical machine. It would seem, therefore, that Newton is in agreement with Galileo on the nature of the physical

[52] *Physics* VIII, 8, 261b31-262b8.

world.

Thus, the mathematical method leads us from the common experience upon which Aristotle bases his physics to a specialized sort of experience called an experiment, and this because it leads from an approach to physics wherein the universal is abstracted from the particular to a "composite" approach wherein the formal is abstracted from the material and then reintroduced to the material. The "mixed" sciences are physical because they rely on direct sense experience of the world and their final appeal is to sensation, but they approach the physical through a more determinate experience than does Aristotle's physics; from, e.g., particular measurements of the orbits of the moons of Jupiter rather than from the mere and obvious fact that things move in some way. It seems our more certain knowledge of the physical world is derived from our more general conceptions precisely because our more general conceptions are based on evident facts, but Newton wants to begin with our more particular experience.[53] And it seems clear, too, that the treatment of nature and the natural ought to be in terms which account for them in the fullness of their being and of our experience of them, not in terms which abstract some one part of their being and of our experience of them. The second procedure, while not to be rejected, must be subordinated to the first. Thus, while Aristotle speaks of the subordination of material sciences to formal sciences, as, for example, optics is subordinated to geometry, St. Thomas in his commentary notes that there are also sciences which are subordinated to others as parts to wholes, as for example optics to the general science of nature. It is along these lines that we would have to criticize Newton's properly physical arguments. For example, the experimentally produced *vacua*

[53] Cf. *Principles*, Bk. III, Rule III, pp. 398-400.

of Boyle must be judged to be really vacua or not in the light of what a general science of nature says about the nature of place, body and so on. Newton's argument that the apparent perpetuity of the paths of the planets leads to saying there is a vacuum outside the atmosphere would have to be judged in the same way, as would his claim that the place of a body is just the sum of the places of its parts. The sources of such a general science are the most common notions of the physical world which we have from our common experience of motion, place, etc.[54]

This subordination of the part to the whole is a result of the way in which men come to know. Since what is most evident to us is not, for example, the particular equation describing this particular motion, but rather the general fact that there is motion, we must start with the most gen-

[54] Arguments against the Newtonian views of place and void are found especially at *Physics* IV, chs. 1-9. It is not difficult to respond to the arguments Newton advances from properly physical principles. The space "evacuated" by Boyle is assumed void on one of two premises: "nothing could get in to replace the air taken out from the bell jar with the air pump," or "there is no pressure there." The latter depends on the accuracy of the instruments for measuring pressure: what would be a void in the seventeenth century would not be a void today, because of the greater precision of modern instruments. The former assumes that the air cannot rarify sufficiently to occupy the whole of the evacuated space. (Objections to this response could also be raised, but I only intend here to indicate the sort of answers which might be offered to the arguments of Newton.) The argument from the motions of the planets likewise depends on the precision of the instruments used. Finally, there is the argument that place equals the contained, but the contained is three-dimensional, therefore, place is three-dimensional. This argument assumes that "equal" means just the same thing in every usage, but it seems perfectly reasonable to say that the place has an equality to the placed which is exactly appropriate to its character as place: place equals the place by containing nothing more or less than the contained. Place measures the placed the way a measuring cup measures flour.

eral and proceed to the more particular.[55] In this descent, there will certainly be room for experiment and mathematical physics. It is the elevation of the mathematical mode of physics to the status of science and even to the status of the sole paradigm of science which seems to me to be erroneous and to have far reaching and regrettable results.

Similarly, the theological underpinnings of Newtonian space are dubious at best. For Aristotle, the existence of a theological subject, of a prime mover independent of the world, is an inference from the physical world considered in its most universal aspects.[56] Our understanding must begin from this sensible world to go to that intellectual world. The beginning of metaphysics is, then, the culmination of physics and is arrived at only through physics. Newton's faith led him to discuss attributes of God, such as His immensity and duration, before having undertaken an analysis of the physical world, even to use this theological discussion as a basis for his physics. Whereas for Aristotle the discussion of the theological can only be a result of the physical and so based on propositions established by physics, Newton leaps by faith to the theological. Starting in the theological he is necessarily drawn to consider his most abstract intuitions, those in the imagination, to be regulative of theology. As Aristotle says,

> Without an image thinking is impossible. For there is in such activity an affection identical with the one in geometrical demonstrations. For in the latter case, though we do

[55] *Physics* I, 1, 184a10-b14. Aristotle does not think that we can deduce particular truths from general ones, but only apply general truths to particular cases. For example, if every motion takes time, the motion of a zebra takes time. This is only an application of a proposition, not a deduction from one. The way zebras move and even the fact that they exist must be established by a particular experience of zebras.

[56] *Physics* VIII, 10, 266a10-267b26.

> not make any use of the fact that the quantity in the triangle is determinate, we nevertheless draw it determinate in quantity. So likewise when one thinks, although the object may not be quantitative, one envisages it as quantitative, though he thinks of it in abstraction from quantity, while, on the other hand, if it is something by nature quantitative but indeterminate, one envisages it as if it had determinate quantity, though one thinks of it only as a quantity.[57]

Thus Newton thinks of God as quantitative because he has not argued to His lack of quantity, as does Aristotle. He merely begins with the image he has of God and tries to make sense of the attributes commonly predicated of God in Christianity, one of which is "immensity," another of which is "infinity." So he interprets these attributes as implying that God is an infinite quantity. From here the step to saying that God is absolute space is very small.

Reducing God to a being of the imagination in this way will lead to saying He is space, for we cannot say He is any of the particular beings we imagine—He must be that unlimited background against which we imagine all other things. A similar argument is used by Newton to establish the existence of the "absolute space" which he seems to identify with God.

These two methodological errors, that of reducing physics to theology and that of reducing it to mathematics, naturally come together; for on this understanding of God, He is best perceived through the imagination and mathematicals seem to reside in the imagination as well. Precisely because of this coincidence, it becomes possible to retain the essence of the Principia without the theological baggage and declare that one has no need of the "hypothesis" of God, as did Newton's French disciple, LaPlace. The mathematization of physics is sufficient not only to banish

[57] *De Memoria*, 1, 450a1-6.

material potency from the world, but divine omnipotence as well.

A comparison with Plato is once again instructive. Both Plato and Newton suppose that what is more abstract is more real. Thus, for Plato, more universal notions refer to more real things; "man" refers to the separate form "man-itself," and the latter is more real than you or me; "animal-itself" is more real yet; most real are being, good, one, different, and other most universal notions. For Newton, the more real abstract entities are quantities as conceived by the mathematician. In St.Thomas' terms, for Plato the abstraction of the universal from the particular is reflective of the structure of reality; for Newton, the abstraction of form from matter.[58]

Now, there is this difference between these two sorts of abstraction: there can be no illusion that the particular dog in front of me is identical with a universal and eternal Dog, but there is every possibility of confusing the quantities around us with those we imagine in mathematics. As Plato saw, the mathematicals are like the sensibles in being many and particular; triangle ABC is different from triangle DEF.[59] And we tend to assume that the quantities of sensible bodes are perfectly conformed to the quantities of the mathematician. Consequently, we may easily fall into the error of identifying geometrical objects with sensible ones. The error is therefore easily popularized and institutionalized, and so can become the philosophy of the masses, as indeed has happened. By contrast, the Platonic error is always seen as a little esoteric.

When the Newtonian error becomes cultural dogma, we have a society based on the view that what we imag-

[58] Cf. St. Thomas Aquinas, *Expositio super librum Boethii De Trinitate*, Q. 5, Art. 1.

[59] Cf. *Metaphysics* I, 6, 987b14-18.

ine is more real than the world as known through the external senses, and yet, oddly enough, that the world, if only we could "get at it," is as intelligible as a Euclidean proposition. (The failure of twentieth century physics to provide a unique and coherent account of the phenomena associated with "sub-atomic particles" is often interpreted as a rejection of the latter point; but the former has held on as tenaciously as ever.) While Plato's view makes the world a mere shadow, but also, therefore, a likeness of the real world of forms, Newton's makes of it an illusion to be discarded in favour of a more perfect mathematical mechanism hidden beneath the surface of concrete reality. Thus, for Plato common speech based on common experience remains a valid starting point for philosophy (as the conversational mode of the dialogues indicates), while for Newton our common modes of speech and thought are to be replaced by mathematical symbols and formulae.

We see this same reduction of the sensible world to the imaginative and of the potencies of nature to act in other aspects of modern thought as well. In physics, time no longer is treated as the adjunct of motion, the "number of motion according to before and after,"[60] but is reduced to an imaginative time-line, every part of which is in act simultaneously. It even becomes possible to ask whether time might not flow backwards, for the order of the parts of time is now seen to be just like the order of the parts of a line. In Newton, it is God's duration, equably flowing from eternity to eternity, heedless of motion and the physical, sensible world of experience. The flow of time which caused Plato to treat the sensible world as almost non-being has been made as real as space.

Matter itself becomes quantified in and of itself. For Aristotle, quantity is an accident of substance, an accident

[60] Physics IV, 11, 219b1-2.

which, in its capacity as immediate subject of qualities such as colour, is material in relation to such qualities, but is nevertheless formal in itself. Matter itself is not a quantity, for in itself it is only potentially this or that, and so only potentially this or that quantity. For each of the great thinkers of the scientific revolution, matter is what is left after we strip the sensible body of its sensible qualities. What is left is a mathematical being, a being of the imagination. The very root of potency has been formalized.

Causes also fall away. If there is no imaginative component to causality, as Hume shows there is not, we must bid it good-bye. If we are to consider things mathematically and formally, we cannot consider the passivity of an object as such, and so we cannot consider new effects as being the actualizations of previously dormant potencies. Since causes are causes only in relation to effects, we can no longer consider causes as producing. We can only know of a miraculous constant conjunction and succession in time. It even seems that formalized time replaces causality. Moreover, the mathematical approach leaves no room for final causes, for the good is not mathematically formulable. Of Aristotle's four causes, only the formal is left, though the shadow of the agent cause lingers for a short time before being transmuted into time itself.

The implication of Aristotle's procedure in discussing God is that God is understood only as a cause of this world, for everything we can know about Him is known through the world as through His effect. If this is right, once we lose any notion of what a cause might be, we are led to atheism or to the arbitrary positing of God through a "leap of faith." In those cases in which there is still faith, the loss of the notion of a cause would lead to the rejection of the hierarchy of secondary causes in the realm of grace. We see this in Luther's rejection of the priests and

sacraments of the Catholic Church.

Politics and morals also are radically altered. If there are no natural potencies in man, there can be no natural fulfillments of those potencies, i.e., no "ends." If so, there can no longer be natural duties, which were understood by Aristotle to be imposed by the perfective power, the final causality, of the actions enjoined and the objects made, the latter being political societies. Instead of this, we must speak only of "rights," of powers to do what we can.

Aristotle speaks of the intellect as being divided into two parts, the active and the passive intellects. When everything is in act, this distinction cannot be made. Sense objects can no longer be impressed on a waiting intellect in an immaterial way by leaving behind some material element, as Aristotle claimed,[61] for there is no such element. When a thing is in the mind, it is there just as it is in reality. Hence, there can be no universals but only classes. This is nominalism, wherein words relate directly to things, not to things by the mediation of concepts, a view which became influential during the late middle ages due to William of Ockham. Such mediation would be useless, since the thing as it is in the mind and the thing as it is in the world are identical according to this view. Consequently, the logician concerns himself not with predication and universal wholes such as animal and man, but with classes, i.e., integral wholes such as the collection of animals or of men. Since these integral wholes contain or exclude each other the way areas on a surface do, i.e., by being outside or inside one another quantitatively (the class or group "man" is in the class or group "animal" because the first class is an integral, quantitative part of the second class), and since the science of such wholes and their relations is mathematics, logic and mathematics

[61] De Anima II, 12, 424a17-24; III, 4-5, 429a10-430a25.

become confounded.

Picking up on the notion that the mind differs from the senses only in degree, not in kind (being less "vivid" than the senses), Hume will say that things are in the mind just as they are in sensation and draw the conclusion that the notions we have are just as incomplete as the experiences they are drawn from. Kant refuses to accept the conclusion, but has to introduce *a priori* categories to save intellectual knowing. These categories are not derived from experience and are full-blown, fully in act, from day one.

All these errors may have other roots as well; all are, perhaps, explicable without reference to each other; but that they have in common a deficient understanding of the primary place of potency in the world is clear. This is also not to say that those who hold these views deny utterly the existence of potency—this would put them in Parmenides' camp—but that they do not see that potency is a principle.

Newton, of course, does not accept all these implications. I only mean to show that the Newtonian view of space is rooted in an attempt to view the world formally and imaginatively and that the consequences of doing so go much beyond our view of space. They affect our views of physics, theology, morality, and epistemology as well.

This desire to view things in a purely formal way seems to be natural for two reasons at least. First, we can only understand the potential in terms of what it is a potential for. Whenever we speak of an ability to do or to suffer, we have to specify what can be done or suffered. The potential is defined in terms of the actual. But what is actual is in some way formal, because the potential becomes actual by attaining some form. Secondly, as Aristotle says in the text quoted earlier, everything we conceive is imagined, though imagining and conceiving are not the same thing. But the imagination presents things as existing in a three-

dimensional space and as quantitative. We seem to be able to imagine away all aspects of things but their dimensionality. Hence, even non-dimensional things are imagined dimensionally. But if we were tricked by this psychological fact into thinking that the world is itself merely dimensional, that the substance of everything around us is mere quantity, we would be treating things formally, for when we treat something only quantitatively we are abstracting from the sensible matter which we perceive through our senses. In terms of our earlier discussion, we are abstracting form from matter. The fact that the actual is more intelligible than the potential also explains the almost universal tendency among physicists to try to reduce all motion to local motion. Aristotle recognizes four sorts of change: locomotion, growth and diminution, alteration, and generation and corruption. Of these four, locomotion seems to involve the least obvious sort of "newness": body A is pretty much the same whether it is here or there. The other three sorts of change, if they are not conceived of as reducible to local motion, more clearly involve something new coming to be, and so more clearly call for a consideration of potency. Perhaps this is why Empedocles thought he could avoid Parmenides' dilemma by reducing all motion to local motion, and why the Atomists thought that if they were going to have to posit an existent non-being to explain any motion, they would posit it to explain local motion and then reduce all other motion to this.

The difference between Aristotelian and Newtonian physics is obviously great, though there is common ground due to the common experience of the world which all men have. This experience seems in its more general and certain aspects to be the experience of a world full of potencies and of a reality reaching far beyond the imagination and mathematics. The fullness of this experience is left aside by Newton for the sake of the intelligibility which

mathematical formalism brings with it. But if the world is not purely formal, such a procedure will necessarily be incomplete and will likely lead to false views about the world. As Aristotle says, in any science, "we must not fail to note the mode of being of the essence and its definition, for, without this, the inquiry is but idle."[62] This is because, if we fail to note the sort of definition we ought to give of our subject, whether, in the present case, we ought to define it with sensible matter or without, as snub-nosed or as curved, we might define it incorrectly and so end up attributing to one thing what applies to another. And even if we define the subject correctly, if we try to treat this subject mathematically we may be misled into proceeding incorrectly, into beginning our science with a too-particular set of experiences, for we will have to look at and measure particular occurrences in the world and sometimes even have to devise experiences to obtain measurements. But an analysis of the experience which forms the context of these more particular experiences would seem to be first in order. This analysis is what Aristotle has left us in his *Physics*.

[62] Metaphysics VI, 1, 1025b28-29.